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ALCOHOL FOR POWER.*

JOHN A. SECOR.†

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GASOLINE is more extensively used for generating power than any other liquid fuel. But although there is an increasing production, the supply is becoming insufficient for the increasing demand, as the output is relatively decreasing when compared with that of crude oil. This is due to the fact that the petroleums from the more recently developed American fields are of different constitution from the oils originally obtained.

Until a comparatively recent period petroleum came chiefly from Pennsylvania and Ohio. These oils vary in gravity from 37 to 50 degrees Baumé and contain approximately from 8 to 12 per cent gasoline. But at the present time Pennsylvania and Ohio with Indiana and Kentucky provide the minimum proportion of the total yield. More than eighty per cent comes from Texas, California, Illinois, and Kansas. These more recently developed oils have specific gravities between 12 and 34 degrees Baumé, and contain only from 1 to 4 per cent gasoline. The available supply of gasoline has been reduced from an average of 10 per cent to less than 3 per cent of the total petroleum production.

Exports of mineral oil increased from seventy-nine million dollars in 1905 to eighty-five millions in 1906, yet it is said that in consequence of the relative shortage in the domestic supply, some gasoline has been imported to this land of petroleum. While the ratio of gasoline to petroleum has decreased, new markets for gasoline have been created which have increased the wholesale price under the inflexible operation of the law of supply and demand. The price of gasoline from the retailer is from 4 cents to 10 cents a gallon above the wholesale price, according to the locality and quantity sold.

The automobile industry in America began with the present century; 314 cars were sold in 1901 and the first complete factories equipped in 1902. It is estimated that 60,000 cars were marketed in 1906 and that over 100,000 will be built during 1907. While the autocar has created a large demand for gasoline, it is believed that the quantity used in the West for gasoline stoves is in excess of the present requirement for automobiles. There is a continuous increase in the gasoline consumption for stationary engines. One firm sold 15,000 engines during 1906. A larger concern is now equipped for making 425 engines per day. The number of engines being sold for farm use alone aggregates about 100,000 annually.

Besides gasoline, the only liquid fuels available for power are the other petroleum derivatives and denatured alcohol. Alcohol is a natural product, resulting from the decomposition of organic tissues under certain requisite conditions of moisture, aeration, and temperature. Its manufacture consists in preparing the raw material, providing the conditions which cause decomposition, and afterward separating the alcohol from the water by distillation, the alcohol having a lower boiling point.

Alcohol in America is made mostly from grain. A small proportion is made from molasses. The non-potable methyl alcohol comes from wood. But alcohol can be made from any form of vegetation containing sufficient sugar or starch to warrant distillation. Among raw materials for making alcohol may be named corn, rye, wheat, sorghum, sugar-beets, potatoes, artichokes, various fruits, and such waste vegetation as corn stalks, corn cobs, sawdust and dry chips of wood. In the South, alcohol is obtainable from sugar cane, and its refuse, rice, yams, and sweet potatoes. Material which decomposes insufficient alcohol for its bulk to pay for transportation is valuable if utilized locally. The bulb of the coffee bean now thrown away in large quantities in the tropics is available alcohol-making material.

The pertinent fact is, that fuel alcohol is a combustible which can be made from materials that are forever inexhaustible as long as the sun shines, and land, water, and labor are obtainable. The present status of alcohol as a fuel for internal combustion engines will now be briefly reviewed.

Alcohol as a Combustible.

As already shown, the petroleums vary greatly in their specific gravity, but the variations in gravity of petroleum, or its products have little effect on the thermal value when based on weight of combustible. Some crude oils develop 21,500 British thermal units per pound. Pennsylvania oil contains an average of 20,736 thermal units. An analysis of fifteen oils from various sources averaged 20,411 thermal units. A conservative estimate for petroleum and its liquid products, including kerosene and gasoline, would approximate 20,000 thermal units per pound. The various oils and gasolines are subdivided into grades which are determined by their specific gravities, but the least variation is in the kerosene group, which are commonly sold as weighing 6½ pounds to the gallon.

Pure alcohol weighs nearly the same as kerosene, or 6.6 pounds per gallon, and contains 12,929 B.T.U. per pound, but anhydrous, "absolute" alcohol is not available as a combustible, for the strongest commercial alcohol contains 5 per cent of water; 94 per cent alcohol develops 11,900 B.T.U., and 90 per cent denatured alcohol may be rated in round numbers at 10,000 B.T.U.

It is sufficiently accurate for the purpose of comparison to say that fuel alcohol has one-half the heating power of gasoline by weight. The heat of combustion when compared with oils and gasolines by volume is as follows:

Combustible.	Weight per gallon. Pounds.	B. T. U. per gallon.
Crude oils, average	7.5	150,000
Distillates, average	7	140,000
Kerosenes, average	6.5	130,000
Gasolines, average	5.8	116,000
90 per cent alcohol, average	7	70,000

Denatured alcohol may therefore be considered to have about 60 per cent of the potential heat of gasoline by volume, and under like conditions of compression and thermodynamic

* For additional information regarding alcohol as a motor fuel, see the following articles, previously published in MACHINERY: Alcohol as a source of power, August, 1905; Alcohol as motor fuel, July, 1906; Alcohol as a fuel for gas engines, August, 1906; The value of alcohol for combustion engines, December, 1906; Alcohol, kerosene, and gasoline as fuels for automobiles, April, 1907.

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‡ John A. Secor was born in New York City, 1847. He began his engineering experience with steam engine construction and design, but recognizing the great future in store for the internal combustion engine, he gave the steam engine over some fifteen years ago, and has since devoted his attention to the internal-combustion type, and the problems connected therewith. His earlier work was an investigation of the various fuels and their proper treatment. As a result he was led to the conclusion that the same general principles should be practically applied to all gas and liquid fuels. The application of these principles to the oil engine has shown that this type can be made a reliable motor, having combustion equal to the gasoline engine and very close regulation, putting it on a par with the best type of gas engine, as witness the high-speed oil engine developed by Mr. Secor. Mr. Secor is the only surviving member of a large family of engineers, his grandfather, father, and five uncles having been marine engine builders from 1835 to 1876, when New York was a shipbuilding center. The Quintard Iron Works was founded by J. A. and J. D. Secor, and the Morgan Iron Works by T. F. Secor in 1838.

efficiency it would require 1 2-3 gallon of alcohol to do the work of one gallon of gasoline.

A well designed modern gas engine using either natural gas, illuminating gas, producer gas, or blast furnace gas will develop a brake horsepower from 10,500 heat units per hour under full load, which gives an efficiency of 24 per cent. Under ordinarily fluctuating loads such engines require about 12,000 heat units per horsepower hour, which represents 20 per cent efficiency.

The compression and consequent efficiency of gasoline engines is slightly less than this, averaging about 19 per cent. Crude oil engines of the low compression vaporizing type as used in the oil regions have an efficiency of 10 per cent. This low efficiency is due to the very low compression and imperfect fuel mixtures, and the Diesel motor using crude oil with high compression and a better mixture has an efficiency higher than the gas engine.

Other things being equal, the fuel efficiency depends upon the compression. A comparison of alcohol as used in a good gasoline engine with other liquid fuels as commonly used for generating power may be tabulated as follows:

Combustible.	Thermal Units B. H. P. hour.	Quantity per B. H. P. hour.	Working Efficiency.
Kerosene	14,500	0.9 pint	19 per cent
Gasoline	14,500	1 pint	19 per cent
Crude oil	25,000	1.3 pint	10 per cent
Alcohol	14,500	1.66 pint	19 per cent

While none of the above efficiencies are the maximum obtainable, they are unnecessarily wasteful for the crude oil and the alcohol. The relative consumption of gasoline and alcohol during the extended fuel test of Maxwell cars between New York and Boston showed about the best efficiency that may be expected with alcohol when used in gasoline engines. The quantity of fuel used in the respective cars was in the proportion of 1 2-3 gallon of alcohol to one gallon of gasoline. The efficiencies of the engines were practically identical; that is to say, the same number of heat units were utilized per horsepower hour in both engines. The conditions of operation were as nearly alike as possible. A stationary gasoline engine tested by Prof. Chas. E. Lucke required 1.8 times as much alcohol as gasoline by weight per horsepower hour. As an approximate statement, it may be considered that the consumption of fuel is doubled when gasoline engines operate on alcohol.

The thermodynamic value of a fuel depends less upon its heat of combustion than upon the number of heat units that may be converted into power. In all internal combustion engines save the Diesel, the compression, and consequently the efficiency, is limited by the ignition temperature of the fuel mixture. In the matter of premature ignition, alcohol has an advantage over the petroleum derivatives. Crude oil has the lowest ignition temperature of all commercial liquid fuels, the distillates come next, then kerosene, gasoline, and finally alcohol follow in ascending order. But the ignition temperature of alcohol is decidedly higher than the critical ignition temperature of gasoline. While, on the one hand, alcohol contains only half the potential heat of gasoline, on the other hand, because of the high ignition temperature of alcohol, it is feasible to double, or triple the degree of compression ordinarily used in oil, or gasoline engines.

The compression in an alcohol engine should not be less than 125 pounds per square inch as a minimum; 150 pounds may be considered as an average compression, the maximum in present practice being around 200 pounds. Much higher compressions are, however, being used in German experimental researches. It is, of course, obvious that when the degree of compression involves undue labor in engines started by cranking, it is requisite to have provision for reducing the compression while starting.

Otto alcohol engines in Germany consume one pint of 93 per cent alcohol per horsepower hour, which is a distinct advance over gas engine practice, as it represents an efficiency of nearly 30 per cent. The best French engines have efficiencies ranging from 30 to 33 per cent. Some German engines have efficiencies of from 35 to 38 per cent; and an engine designed by Prof. Ernst Mayer is said to have an efficiency of 39½ per cent.

All these engines control the ignition temperature by adding certain proportions of water to the fuel mixture, the quantity increasing with the compression. The advantage of using water for this purpose in engines which have high compression is now conceded. But as the petroleum distillates do not mix with water, and an excess of water is deleterious, it must be added to each separate fuel charge with skillful manipulation. Alcohol, however, has an affinity for, and mixes readily with, water when poured into the same vessel. As alcohol and water form a perfectly uniform mixture, the proportions required in order to control the excess heat developed by compression may be measured accurately.

Alcohol is the least exacting of the liquid fuels in the matters of compression and fuel mixture proportions. The heavy oils and gasolines are restricted to comparatively low compressions. The "lean" fuels, which have low potential heat in proportion to bulk, like blast furnace or producer gas, require high compression. It is possible to use alcohol with any compression, and the only point to be considered is efficiency. Again, oil fuel mixtures should be in absolutely correct proportions; a slight variation from the critical proportions causes non-inflammability when the proportion of fuel is insufficient, or smoky combustion when in excess. The gasoline fuel mixtures have a somewhat wider range of admissible proportions; but alcohol is far more flexible in this respect than the hydrocarbons. While this increases the factor of reliability in an alcohol engine, it also increases the possibility of inefficiency in design and operation. It has been found that alcohol is not as well adapted for engines which have "hit-or-miss" regulation as for engines which are governed by "throttling" the mixture.

The action of the working fluid in an alcohol engine is somewhat similar to that of steam in a steam engine. The exhaust is cooler, and less heat is carried off by the jacket water than in gasoline engines. In automobile engines there is a perceptible diminution in the tendency to "pound." An alcohol car negotiates steep grades with greater facility than the gasoline car.

It is probable that alcohol is better adapted for air cooled cars than gasoline in consequence of the reduction in heat; and it is possible that alcohol may also be a suitable fuel for compound internal combustion engines, as the discharged products of combustion contain water vapor surcharged with latent heat.

Alcohol in Germany.

Germany has thus far made more actual progress in the use of alcohol for power than any other country. Several other European governments have, however, removed the tax from alcohol for industrial use; England for example, has had free denatured alcohol for fifty years. The progress which Germany has made toward the use of fuel alcohol is due to the united efforts of the government, the farmers, the distillers, the engine makers, and the users of power.

Alcohol in Germany is made chiefly from the potato and sugar-beet refuse. The price at which it can be manufactured profitably has thus far largely confined its use to engines below fifteen horsepower. It is said that, notwithstanding its recent introduction as a fuel, more than five thousand alcohol engines are now in use.

The German tax on denatured alcohol has been remitted for twenty years, but, its commercial use as a combustible is recent. There was an overproduction in the potato crop during 1901 and it was decided to turn the surplus into alcohol. The unusual increase in the supply of alcohol naturally caused a serious fall in its price. The government then decided to hold an Alcohol Exposition in Berlin during 1902 for the exclusive purpose of demonstrating the feasibility and advantages of alcohol as a source of light, heat, and power. Among other exhibits was a fifty-horsepower electric light plant operated by an alcohol engine. Several other alcohol exhibitions have been promoted by the government since 1902 for the purpose of popularizing the new combustible. The German alcohol law is extremely liberal, and as a result small stills are in operation which produce even less than twenty gallons per month.

Alcohol in the United States.

The removal of the tax on denatured alcohol made in the United States after January first of the present year did not have the effect anticipated by many. Some technical journals predicted that the price would drop to ten or fifteen cents per gallon. But it was found that the farm distillery was just as effectually prohibited from making alcohol as if the new law had not been enacted.

There was no change in the requirement of a special construction of the distillery. Every distillery must be surveyed and approved by an authorized revenue officer. The usual deeds which give the government a first lien on the ground occupied must be executed, and the usual distiller's bond must be given before the distillery could be registered and permitted to operate. Even the smallest distillery must have a separate bonded warehouse and separate denaturing room. The bonded warehouse and denaturing room must be constructed like a fortress and locked to prevent the admission of any one unaccompanied by a government officer. Even the various pipes leading from vats, water tanks, stills, etc., must be provided with locks and keys, and the pipes distinguished by being painted certain specified colors. Furthermore, a storekeeper and gager, or a storekeeper-gager must be assigned to each distillery. A government officer must be on guard day and night, including Sundays and holidays. The law also limits the minimum quantity which can be distilled, by prohibiting the operation of any distillery which mashes less than one hundred bushels of grain every day. The law also prohibits the distillation of low proof alcohol. The lowest proof permissible is 180 degrees which is equivalent to 90 per cent alcohol and involves redistillation. The alcohol usually manufactured is 188 degrees proof.

While the present law thus gives the large distiller a monopoly of supplying fuel alcohol, its market price is increased by the statutory requirement in regard to the mode of denaturing. The law provides that "to every 100 parts by volume of ethyl alcohol of the desired proof (not less than 180 degrees) there shall be added 10 parts by volume of approved methyl alcohol and one-half of one part by volume of approved benzine." The price of the wood alcohol thus adds materially to the cost of the denatured product. Alcohol is also denatured for special purposes, but not for general use, by means of pure nicotine and aniline dyes at a cost of less than one cent per gallon.

The market price of denatured alcohol is still further increased by the present limitation on the quantity which can be legally transported in a single package. Fuel alcohol cannot be transported in tank cars like petroleum; it must be shipped in barrels, or equivalent receptacles. It is evident that the cost of freightage is a matter of prime importance in reducing the price of alcohol for power to a competing basis with other liquid fuels which can be shipped in bulk to those sections which are distant from central points of distribution.

In view of these restrictions which practically prohibit the installation of the farm distillery, it is evident that one of the most important acts of legislation passed at the last session of Congress was Senator Hansbrough's amendments to the free alcohol law. The amended law does not take effect until September, but it will then be permissible for anyone who complies with regulations which the Commissioner of Internal Revenue is required to issue, to distil on his own premises a quantity of alcohol not exceeding a hundred gallons daily. The smallest producer may distil alcohol, as it does not matter how much less he produces, or how long his still remains idle. The farm distillery can then produce a fuel capable of developing upward of eighty horsepower for ten hours daily from material grown on the farm.

Some Misstatements Corrected.

Misleading statements have been made, in relation to the alcohol engine, which should be corrected. Among these may be named the following:

1. "Any good gasoline engine is adapted to use alcohol."

This is incorrect. No gasoline engine can use alcohol with economy. It is true, as the writer has already conceded, that "any engine on the American market to-day, operating with gasoline or kerosene, can operate with alcohol fuel without any structural change whatever, with proper manipulation." But, if it is considered wasteful to use gasoline in an oil engine of the low compression type, it is far more wasteful to use alcohol in engines which have compressions designed for gasoline. The compression in an internal combustion engine should be adapted for the specific fuel on which it operates.

2. "The difference between gasoline and alcohol is not sufficient to require any material change in size of cylinders."

This also is incorrect. Alcohol requires less air than gasoline per pound of combustible. While making provision for higher compression, cylinder diameters may be reduced. For any given power the cylinder area should be about fifteen per cent less than in standard gasoline engine practice.

3. "Any good gasoline carbureter is adapted for alcohol when the fuel mixture proportions have been properly adjusted."

This is incorrect. No gasoline carbureter will start satisfactorily with alcohol. The inability to use alcohol in gasoline carbureters for starting has led many authorities to assert that "an engine cannot be started with alcohol." Gasoline is almost universally used in Germany for starting alcohol engines. In a few cases alcohol is used after heating the carbureter.

There is no difficulty in starting by means of alcohol, if used in a properly designed carbureter. The writer uses alcohol for starting kerosene engines as well as alcohol engines. When starting an engine with any volatile liquid fuel, it is important to have a uniform and correctly proportioned mixture. As alcohol is less volatile than gasoline, these conditions are absolutely essential when starting with alcohol.

The inability to start with alcohol arises from the uncertain mixture made by the gasoline carbureter. In Bulletin 277 issued by the U. S. Department of Agriculture, Prof. Chas. E. Lucke states that although some "vaporizers and carbureters to some extent will maintain the mixture perfectly well for some rate of flow, or some particular temperature, no carbureter that has ever come to our attention will maintain an absolutely correct mixture for high speed and low speed, cold or hot air, moist or dry air, or changes in the rate of supply or engine load that must be met with in practical operation."

It has not been sufficiently recognized that it is even more important to have correctly proportioned and uniform fuel mixtures in engines operating on liquid fuels than it is in gas engines. But in a throttling engine the carbureter should automatically vary the proportions of fuel and air to suit the compression. By complying with the required conditions an engine can be started with either grain, molasses, or methyl alcohol.

4. "Up to the present, tests made with denatured alcohol alone have proven that as a fuel it is of value only in comparatively slow engines, no test at more than 400 revolutions per minute having resulted satisfactorily. Denatured alcohol is too slow in vaporizing and in explosion to give effective value as power in high speed motors."

This statement is absolutely erroneous. The present writer has operated alcohol engines without difficulty at various rotation rates between 400 and 1,200 R.P.M.

5. "Alcohol will oxidize the valves and interior of the cylinder."

This is misleading and should be contradicted, as it does not occur with engines in daily use. When an engine is used irregularly, it is advisable to occasionally examine the interior and remove moisture, if found.

General Conclusions.

The principles of correct engine designing and of thermodynamic efficiency are, of course, independent of the fuel used, and the various fuels are all used in engines of a common type. But in designing an engine, the qualities of its fuel must be considered and provided for. In order to determine cylinder volumes and compressions, it is necessary to know the amount of heat developed by the combustible, the volume of air required for complete combustion under the working conditions, the ignition temperature of the fuel mixture, and the mean effective working pressure. The conditions under which combustion should occur are also independent of the

quality or form of the combustible, and are the same for all gas or liquid fuels. If the fuel mixture is perfectly homogeneous—thoroughly intermingled—and correctly proportioned, the combustion will be complete.

It is now perfectly feasible to comply with these basic conditions in oil engines, which have colorless combustion at any load, combined with such sensitive regulation as to confine the variation of voltage within one per cent when direct-coupled to electric generators. Oil engines which are not too cold under light load, nor too hot under full load, will unquestionably replace gasoline engines in the future.

The market price of alcohol under the amended law may not be as low as some have anticipated. It will be difficult for a manufactured fuel to compete with oil at its present price; and for some time to come the price of corn will be a controlling factor in fixing the price of alcohol. It is probable, however, that the alcohol autocar will be shortly in evidence; for as soon as the demand arises, manufacturers will supply cars fitted with engines and carbureters adapted for alcohol.

Ordinary kerosene oil can also be, and probably will be, used, especially for trucks and business wagons. The carbureters will automatically maintain correct mixtures at all speeds, loads, and grades of road.

But the more immediate and important market for the alcohol engine will be for general farm use and for irrigation. In many cases alcohol will be the cheapest and most available fuel. The raw material will frequently have little or no value, and the cost of hauling raw material and alcohol will be practically eliminated when used locally. In such situations the alcohol engine will create and command its own market.

The pumping of water for irrigation and drainage has assumed considerable importance since the reclamation law was enacted by Congress in 1902. Eight towns have been built, and 10,000 people settled on what were desert lands. Sixty millions of acres of arid land are subject to irrigation and can be converted into farms fully as productive as those in the most favored sections. Approximately ten per cent of this arid land, or 600,000 acres, are already irrigated by means of 1,267 miles of canals. A large part of this unreclaimed land can get water in no other way; and as a rule it is so located that fuel of any kind is difficult to get. Alcohol offers in such cases a hope of cheaper fuel, which may mean the reclamation of large areas, since the land irrigated can produce the fuel to maintain its water supply.

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THE RATIO OF EFFECTIVE PRESSURE WITH TOGGLE-JOINTS.

W. H. BUTZ.*

The toggle-joint seems to be somewhat of an unknown quantity to the majority of draftsmen. Theoretically they may be able to figure the increase in pressure to be obtained from it with the lever arms at a given angle, but beyond this their experience does not extend. At a first glance the following may seem to be a simple case of figuring the theoretical pressure, and allowing a liberal percentage of loss for friction, depending on the type of bearings, bearing pressures, lubrication, etc. But looking into it a little further, we will see this is not so. Most machines embodying the toggle-joint are so designed, that when the greatest pressure is being exerted, the joint is straightened out, or nearly enough to call it so. This article deals with maximum results obtained from this type of machine only when the toggle-joint is straightened out. Disregarding friction, this means such an enormous increase in power, that it would be out of the question to figure on getting it in actual practice. Now let us consider the formula for toggle-joints:

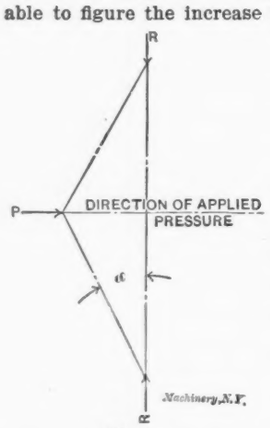

Fig. 1.

In Fig. 1, P = power applied,

R = resistance,

α = angle of lever arms from straight line.

Then the formula is

$$2\,R \sin \alpha = P \cos \alpha, \text{ and}$$

$$\frac{R}{P} = \frac{\cos \alpha}{2 \sin \alpha} = \text{ratio of resistance to power applied,}$$

or $R = P \times$ ratio.

Having occasion to design a portable pneumatic riveting machine of the type shown in Fig. 2, the question arose how to calculate for R. If the toggle be straightened out, R becomes practically infinite, or if the angle α be, say, only one

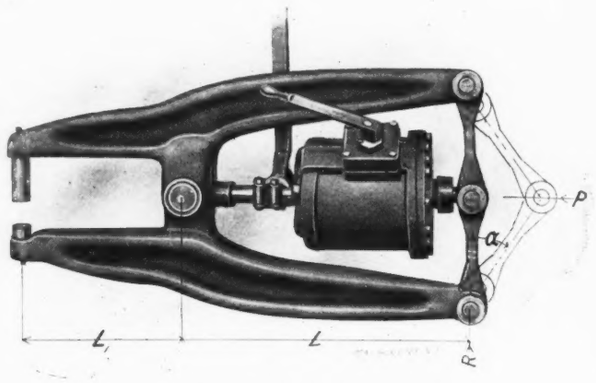

Fig. 2. Alligator Type of Toggle-joint Riveter.

degree, we still have an enormous quantity for R, not knowing what coefficient of friction to allow. Finally I decided to make angle α fairly large, and to figure for R, and consider that R would be my final pressure, even though the toggle were straightened out.

On the machine as designed, Fig. 2, the cylinder was about 11.9 inches diameter (piston rod 1½ inch) and the working pressure 80 pounds per square inch. This gave me 8,900 pounds for P.

Deciding on 3¾ degrees for α, the ratio of R to P, according to the formula, was as 7.64 to 1. Hence 8,900 pounds × 7.64 = 68,000 pounds for R.

In Fig. 2, $L = 23\frac{1}{2}$ inches, and

$L_1 = 24\frac{3}{4}$ inches.

Then $\dfrac{68{,}000 \times 23.5}{24.75} = 64{,}500$ pounds on the dies, or 32 tons, which was the effective pressure required on this machine.

When the machine was built and tested, the highest pressure obtained on the dies was eighteen tons, showing that there was enormous loss in the machine, somewhere, but as the bearings were all amply large and well lubricated, we could only surmise that the efficiency of the toggle-joint was not nearly as high as generally supposed. If we shortened the distance between the dies so little as 1/32 inch, the cylinder could not exert sufficient pressure to straighten out the toggle-joint, and the pressure on the dies dropped. It was then up to me to design the machine over again.

Taking the eighteen tons die pressure as a basis, and figuring back through the machine, I found that

$$R = \frac{36{,}000 \times 24.75}{23.5} = 37{,}900 \text{ pounds,}$$

then $\dfrac{37{,}900}{8{,}900} = 4.26 =$ effective ratio, for an angle α of 3¾ deg.

Now having a ratio to work with, I designed a second machine having a 13-inch cylinder, 2-inch piston rod, length L, 37½ inches, L_1, 25 inches, and working pressure 80 pounds.

Using formula $R = P \times$ ratio.

$R = 10{,}370$ pounds × 4.26 = 44,200 pounds,

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$$\frac{44{,}200 \times 37.5}{25} = 66{,}250 \text{ pounds on dies, or } 33\tfrac{1}{8} \text{ tons.}$$

This machine when tested, gave an effective pressure of 33 tons on the dies, which corresponded exactly to tests made on the other machine, with regard to efficiency.

In testing these machines, we used the arrangement shown in Fig. 3. It consisted of a steel shell, *A*, with walls heavy enough to stand the high pressure, which in some cases approached 8,000 pounds per square inch, and a straight plug, *B*, fitting into same. The chamber, *C*, was filled with oil, and tapped into for a pipe running to the gage, which registered directly in tons the pressure on the plug, which was 4½ inches diameter. The gage was made expressly for testing our riveters, and is frequently tested by the makers to insure accuracy.

The question might be raised as to how we knew that the toggles were straightened out when the maximum pressure was obtained. This is very easily answered. The machines were designed and assembled so that when the piston had reached the end of its stroke, the toggle was straight. Now, in testing, when the toggle did straighten out, the piston went up with a rush. If the toggle did not straighten out, it always staid off the straight line by as much as two or three inches. So there could be absolutely no question as to whether the toggle did or did not straighten out. The screws could be adjusted, and the tonnage gradually raised to the maximum; after that, a movement of 1/32 or 1/16 inch more was sufficient to prevent the straightening out of the toggle by the amount before stated. This has been my experience with toggle joints, but I cannot say whether this same ratio would apply

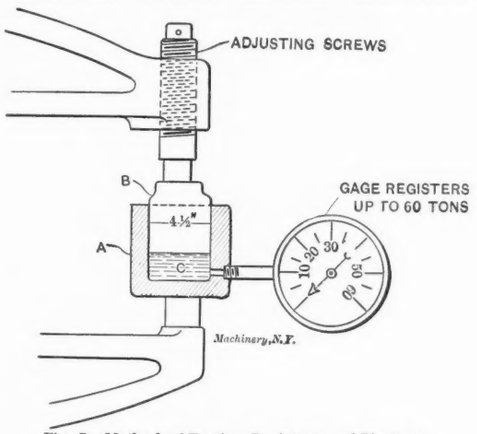

Fig. 3. Method of Testing Resistance of Riveters.

to other types of machines, such as stone crushers, etc., where the energy is stored in a rapidly moving flywheel. If any one could give me more information on the subject, I would like to hear from them.

[The experience of Mr. Butz would seem to indicate that for the chosen angle the efficiency of the toggle-joint was only 55.75 per cent, and that the difference—44.25 per cent—was lost in friction in a slow moving mechanism. There is, however, a feature to be considered which entirely changes the complexion of the above experience, and that is the spring of the mechanism which causes work to be lost in simply deflecting the lever arms. If the lever arms had been stiffened it would have been found that the efficiency of the toggle was much higher than that indicated by the experiment. In fact it may be safely stated that the test gave practically no measure of the efficiency of the toggle-joint alone, inasmuch as another factor enters that vitally affected the result.—EDITOR.]

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At the same time that a great many prizes have been offered for a practical flying machine, the Dutch government is contemplating a tax on aeronauts who descend in that country. The tax amounts to about $400 for each descent, and if not paid, can be converted into three months in prison. This somewhat radical measure has been prompted by the fact that almost all aeronauts who descend in Holland are German army officers upon which the authorities look with more or less suspicion.

THE CASE-HARDENING FURNACE.*

ITS USE FOR HARDENING, COLORING AND MOTTLING.

J. F. SALLOWS.†

No doubt the majority of tool-steel workers know that heating high-carbon steel in a gas or any open furnace without packing, oxidizes and decarbonizes the steel, making it impossible to obtain a uniform hardness. Lead baths have their disadvantages, and, in fact, my experience leads me to believe that lead baths in general are a nuisance and of very little value. The method of pack-hardening and dipping described

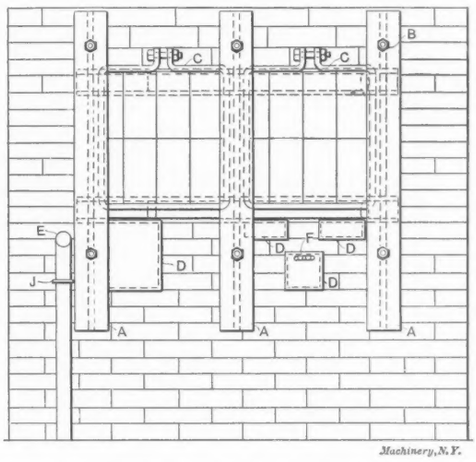

Fig. 1. Front View of Case-hardening Furnace.

in the course of this article has given me the most satisfactory results, but first we must have a furnace suited to such work.

The Case-hardening Furnace.

The case-hardening furnace shown in Figs. 1, 2, 3, and 4 is about the best hard coal furnace I have seen for pack-hardening, case-hardening, mottling and coloring. It can be built from common brick and fire-brick, and is large enough for an ordinary shop. If a larger one is required, it will be necessary to use large tile in place of fire-brick for the bottom of the oven. A blast is used in connection with this furnace

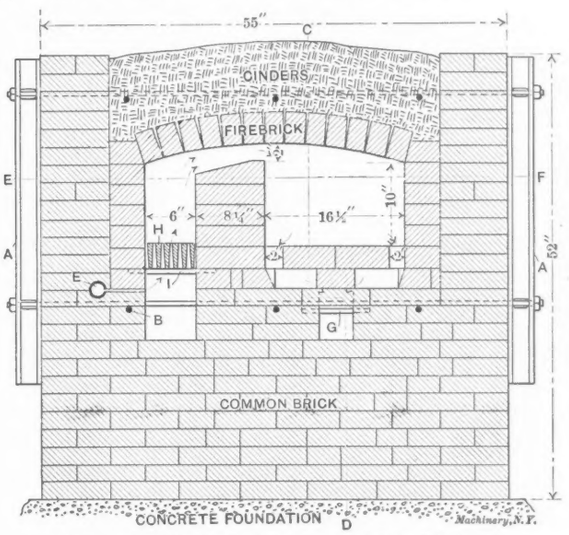

Fig. 2. Case-hardening Furnace. Section in A-B, Fig. 3.

when starting the fire, but very little is required after the boxes containing the work to be hardened are red-hot, but this, of course, depends upon the draft in the chimney. A damper should be supplied in the pipe behind the furnace to regulate the heat. The following are the principal parts of the furnace: *A*, cast iron buck-stays; *B*, ⅝-inch stay-bolts; *C*, door frame, ¾ x 1¾-inch iron; *D*, sheet iron caps for flues; *E*, blast

* The following articles on the subject of case-hardening and case-hardening furnaces have previously appeared in MACHINERY: Case-hardening, August, 1905; Case-hardening Wrought Iron, October, 1906; The Drop Forge and Hardening Plant, April, 1907.

† Address: Reo Motor Car Co., Lansing, Mich.

pipe, 1½inch gas pipe, slotted; *F*, damper; *G*, damper support; *H*, cast iron grate; *I*, grate support; *J*, blast shut-off; and *K*, stack.

Packing Steel for Hardening.

Now, in packing tool steel parts for hardening, do not use raw bone or leather unless you are using a low-carbon steel and wish to supply more carbon. The steel generally used for such tools as reamers, shears, etc., is high-carbon, and by

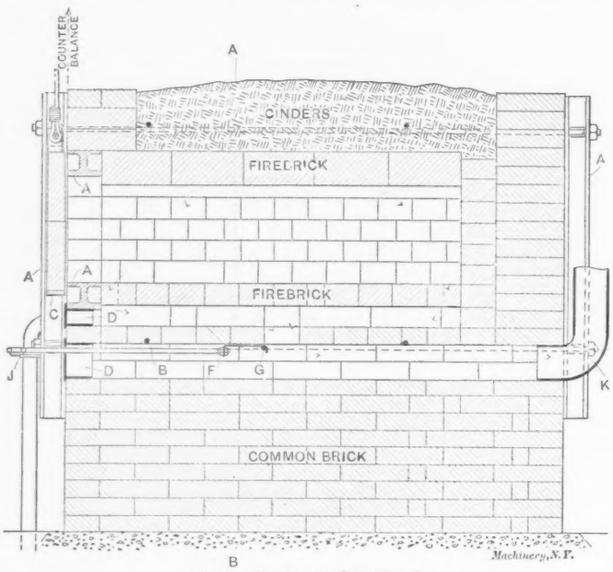

Fig. 3. Section in C-D, Fig. 2.

packing in raw bone we shall get the cutting parts too brittle. Use instead only fine wood charcoal about the size of kernels of corn. Fig. 5 is not the best kind of box to use for this kind of work, as the parts cannot be properly packed in it, and if very long they cannot be gotten out without bending. Fig. 6 is about the correct thing. Seal the cover on with asbestos cement and put a few ¼-inch rods down through holes drilled in the cover. After the work has been in the oven a reason-

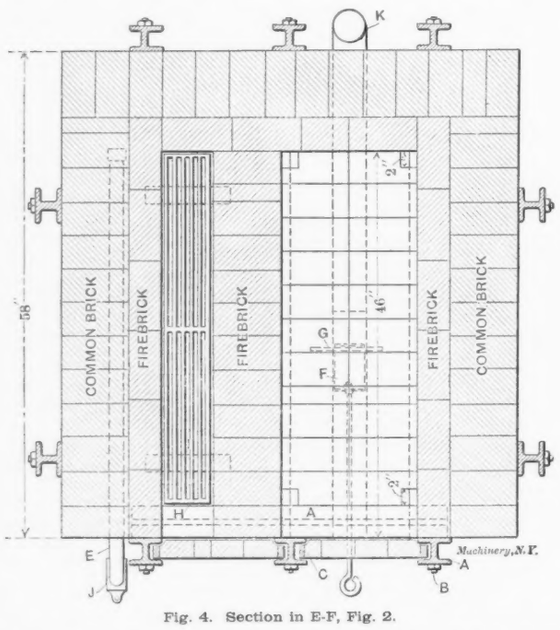

Fig. 4. Section in E-F, Fig. 2.

able length of time, take out one of the rods; if hot enough, draw the box out, pick the work out, and dip. But, if the rod is not hot enough, replace the box, and after half an hour draw another rod, and repeat, if necessary, until one is pulled that shows that the proper heat has been reached.

Dipping Work.

When dipping work of this kind use salt water, and never use clear water only, because the parts do not chill quickly enough. When dipping a tool in water, do not start off sidewise when immersing the object, the reason being that one side of the tool will be exposed to cold water, and hot water and steam will be following up the other side, thus causing warped work and uneven hardening. We all know that hot water comes quickly to the top, so provide a deep tank of cold salt water and start the work in straight; carry it clear down to the bottom of the tank and then raise it slowly up again. Instead of leaving it in the water until entirely cold, remove while quite warm to a tank of fish oil to draw down and relieve the strain. The reamers shown in the cut, Fig. 10, were heated in a large gas-pipe, the same as that indicated in Fig. 7, and were dipped in cold salt water just long enough to harden the cutting parts. They were then removed to a tank of fish oil and left there until cold. The cut shows them in a sieve as they were drawn from the oil. There are fourteen of the reamers, ranging in size from 1 to 1⅝ inch diameter, and in length of cutting edges from 5 to 12 inches. These reamers have given remarkable satisfaction. The method is much quicker than the old way of cooling completely in clear water, then cleaning up and drawing down the temper, to say nothing of the danger of cracking before this time-killing and edge-destroying practice is completed.

The gas-pipe is a very convenient holder for packing work for hardening, as it can be rolled over easily to get a uniform heat. To make it, rivet a thin plug of machine steel in one end, and after the work is packed, plug the other end with asbestos cement. Take, for example, some long thin blades

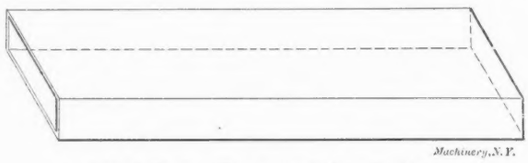

Fig. 5. Form of Box not suited for Packing.

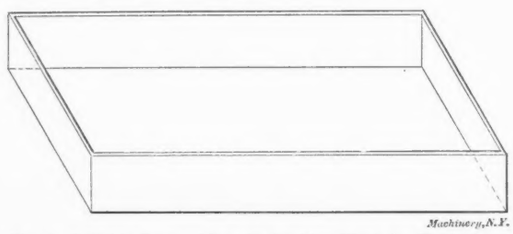

Fig. 6. Suitable Form of Box for Packing Work for Hardening.

about 12 inches long or less, ½ inch wide and ⅛ inch thick; it is a difficult task to harden this class of work and keep it straight. The writer has repeatedly hardened such blades and kept them perfectly straight by arranging them as shown in Fig. 8. Make three small clamps like *C* long enough to take in from 12 to 16 blades; then fasten one clamp on each end and one in the center of the blades. The blades should be a little higher than the clamp so as to allow the top part of the clamp *B* to bind on the edges of blades *D* when tightened down with the cap-screws, *A*. Then pack in the pipe or open-top box in wood charcoal, heat and dip same as explained about reamers. High-speed steel blades can be treated this way, but must be brought to a much higher heat—just as hot as a hard coal furnace will make them. They should be dipped in hot salt water and removed to the oil bath while a little warm, and let remain there until cold. This treatment will make them very hard and at the same time keep them straight.

Use of Furnace for Cyanide Hardening.

This same furnace is invaluable for hardening with cyanide. Put a box containing potassium cyanide in the furnace and heat it to a bright cherry red. Put the work to be hardened in an open furnace and heat to the same heat as the cyanide. Then place the work in the cyanide and let it remain for from five to twenty-five minutes, according to the depth desired. Then take the work out of the box and cool off in some light oil—kerosene is the best. Keep a cover on the box while heating the cyanide; just put it on loosely and do not seal. Cyanide should always be kept in air-tight cans, as it will air-slake if exposed, and will not melt if it has been exposed for any considerable length of time.

Hardening for Colors.

When hardening for colors, a furnace like the one described is necessary. The writer has worked out a method of coloring which at the same time hardens deep enough for the class of work desired to be colored, such as wrenches, crank levers for automobiles, nuts, etc. The method is as follows: Mix 10 parts charred bone, 6 parts wood charcoal, 4 parts charred leather and 1 part powdered cyanide. The charred bone may

Fig. 7. Section of Gas-pipe Holder.

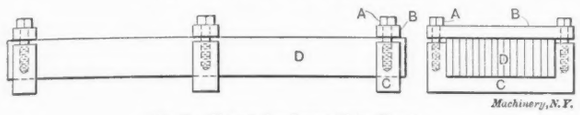

Fig. 8. Clamp for Long Thin Work.

be obtained by placing a few boxes of raw bone in the furnace on Saturday night (if the furnace is not run over Sunday). If much fire is in the fire-box it should be drawn, as the heat in the furnace will be sufficient to char the bone to a dark brown. The charred leather may be obtained in the same way. The leather should be black, crisp and well pulverized, and the four ingredients should be well mixed together. The object in charring the bone and leather is to remove all grease. The parts to be colored must be well polished and they should not be handled with greasy hands. These rules must be observed if a nice class of work is desired.

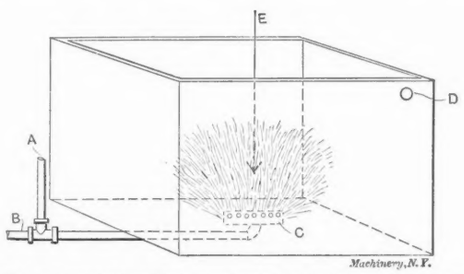

Fig. 9. Hardening Tank arranged for Mottling and Coloring.

If the colors obtained are too gaudy, the cyanide may be left out, and if there is still too much color leave out the charcoal. When packing parts to be colored and hardened, they should

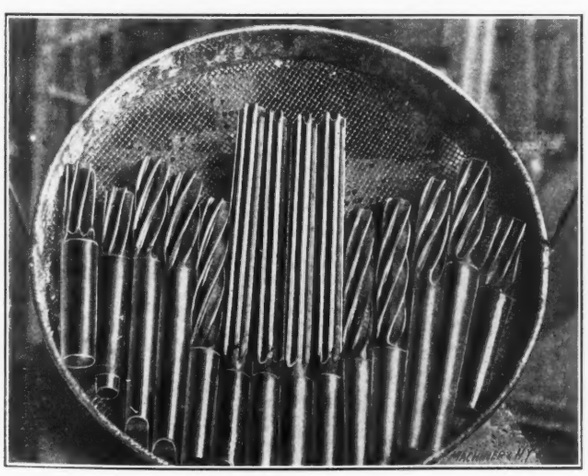

Fig. 10. Hardened Reamers, just Removed from Oil Bath.

be packed in a common gas-pipe, for the reason that when dumping into the water the parts must not be exposed to the air, and a pipe is much easier to handle than any other shape. The open end can be brought down close to the top of the water before the parts are liable to come out, but not so with a box, for just as soon as a box is tipped a little the parts begin to fall out, and become exposed to the air.

In heating this class of work, heat to a dark cherry red and keep at that heat for about four or five hours; if heated too hot no colors will appear. To harden and color the work when dumped, a tank must be arranged as shown in Fig. 9. A compressed-air pipe *A* must be connected with the water pipe *B*, and a large cap *C* should be drilled full of ¼-inch holes on top and around the sides. An overflow *D* should also be supplied. Fill the tank with water, then turn on air enough to fill the tank with lively bubbles and dump the work in the center, as shown at *E*. When the work is all dumped, pull up the sieve which should be in the tank for the work to fall on, pick the work out and place it in pails of boiling water drawn from the boiler; let remain for five minutes and then remove to a box of dry sawdust for half an hour; remove and dust off and give a coating of oil or lacquer. This method is the result of a great deal of experimenting by the writer, and produces a fine class of coloring.

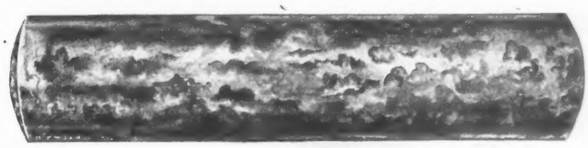

Fig. 11. Sample of Work Case-hardened for Colors.

[Fig. 11 shows a sample of work case-hardened for colors by Mr. Sallows, but the cut gives a very poor idea of its beauty.—EDITOR.]

* * *

EXTREME CONDITIONS OF UTILIZATION OF WATER POWER.

The *Times Engineering Supplement* gives some interesting information about the extreme conditions which the hydraulic engineer meets with. At the present time there are turbines working under the enormous effective head of 3,018 feet, and there also are turbines working under a head of only 2 feet. The former is installed at Lake Tanay, and is at present the highest utilized head in the world. In this country there is an installation at Manitou, near Colorado Springs, which works at an effective head of 2,200 feet. The low head plant referred to is driving a mill near Worcester. The turbine is a parallel flow wheel with a vertical shaft, the diameter of the wheel being 13 feet 2 inches. It is made up of two concentric rings of buckets, of which the inner set can be closed to the passage of water, so as to limit the operation of the wheel to the outer ring. As the flow of water in the river is variable, a head of 3 feet in certain periods acts upon the wheel, and the 40 horse-power required to drive the mill is obtained from the outer ring alone, but at other seasons of the year when the fall is reduced to 2 feet and even less, the full capacity of the wheel is utilized. This gives an example of how, in small rivers in which the amount of the discharge of water can be fairly well relied upon, a very moderate head of water may be turned into profitable use. The cost of the turbine installation, excluding the cost of foundations and special work depending on the local conditions, is approximately $150 per horse-power. The chief object of the foregoing remarks is to point out what has been done in utilizing water power under extreme conditions. Each problem, depending as it does on commercial considerations, has to be solved independently, and in some cases it will be found that the cost of the development of the water power precludes the possibility of any advantage over steam power, while in others a waste of natural power may be turned to good use.

* * *

The Pennsylvania Railroad has ordered 200 steel passenger cars to be built by the American Car & Foundry Co., The Pressed Steel Car Co., and the Altoona shops of the Pennsylvania Railroad in the proportion of 95, 80, and 25 respectively. The new cars will be of extraordinary strength and are so-called collision-proof. It is the aim of the company to have all steel passenger cars in service when the New York terminal is completed, and at least 1,000 steel coaches and 500 Pullmans are expected to be in use within a few years.

WAGES VS. ABILITY.

MANUFACTURER.

Lately we have heard and read a great deal about the scarcity of skilled tool-makers and machinists, and the manufacturers wonder why the boys do not enter the shops as apprentices as in days of old. When we consider the wages paid for clerking, counter jumping and for outdoor tradesmen, it is no wonder that the present generation of boys prefer the latter positions to taking up work in a dirty, foul-smelling machine shop. The manufacturers have drawn a hard and fast line between a man's ability and his wages, and really the ones to blame are the manufacturers themselves.

For instance, a tool-maker applies for a position and is informed that there is a position open for a first-class man, expert on models, gages, and all kinds of punch and die work, and when the question of wages comes up, he is informed that 35 cents per hour is all that they can pay, as it is against the rules of the company to pay more to a tool-maker. Now right here is just where the manufacturers are making a fatal mistake by placing a limit on the wage scale. It removes incentive, and that removes ambition. A visit in tool-rooms of most large corporations will find men roughing out work preparatory to turning the job over to a more skilled workman to finish. But, by a long term of service, this roughing out man has succeeded in obtaining 35 cents per hour, which is the same rate paid the man that must finish the job and stand the responsibility. There will also be found others in the rooms that are receiving the limit in wages, but who, from lack of experience or pure ignorance, are unable to satisfactorily complete a job requiring accuracy. Bosses that read this will say, "Well there are none in my room," but there you are wrong, as there are few tool-rooms, indeed, that do not contain one or more men that are secretly instructed by others in the room as to how they should proceed to complete their job. They get their job through nerve, and hold it through their fellow workmen.

Therefore, when a workman is frankly told that he is receiving the limit, that, "we absolutely refuse to pay more," is it any wonder that the mechanic loses ambition? He mentally compares his chosen calling, number of hours he is obliged to work, and wages received, to other trades requiring less skill and working shorter hours, the result being that he advocates unionism to better his own condition and discourages his boys or friend's boys from entering the trade. Many will argue that a fine workman will surely forge ahead and receive more than his fellow workmen. This is true to some extent in small shops, where a man's worth is appreciated, but in a large corporation where nearly all offices are secured and held through family ties or some sort of a pull, the superior workman is nothing more than a plank in the floor. Hundreds of readers can recall instances where their superiors are filling positions that they secured through "pull," and are holding their places through their men under them. A good illustration of what I mean when I speak of drawing the line between ability and wages happened two years ago when the writer first started in the manufacturing business. All my belts being new, they, of course, slipped considerably, and I called on my former superintendent, wishing to purchase some belt dressing. "Ha, ha," says he, "now that you are in business for yourself, you are particular to have your belts grip, aren't you?" I replied that it was perfectly natural, as it affected my own pocket. The superintendent replied that it was always a puzzle to him why a man did not take the same interest in his work, keeping the belts tight, taking heavy chips, etc., when working for some one else that he did when working for himself. I told him frankly that when entering his employ the men are given to distinctly understand that the wage scale is set, and that under no circumstances will the workmen receive more, and that very thing removes the incentive for a man to hustle, as he knows that no matter how much he does or how well he does it, he will not receive more than their set price. Considering that the company has taken that stand toward the help, it is unnatural to expect that the help will work in anything but a listless manner. He replied that he thought that I looked at it in a wrong light, "for," says he, "when a boy starts at the machinist's trade, he must work faithfully and will soon be promoted to finer work; then as he becomes proficient in machine work, he is promoted to tool work, and when he has reached the top notch in tool work, he is placed foreman and so on." I agreed with him that the boys do strive to better themselves, for that was what prompted them to learn the trade, but my argument was that when they receive a certain price the line is drawn, and that they cannot advance further without "pull," except in a few instances. To substantiate my argument, I cited a case that happened two weeks before our conversation (in that same shop). There was in the engineering department an exceptionally bright young man, whom we will call Howard. He was employed laying out curve drawings, gear ratios for various trains for clock work, made tests of electrical instruments, did all of the photography work for electrotyping, and designed and made working drawings of tools for fine electrical measuring instruments, and in return he received $1.75 per day. He was apparently contented until a former superintendent, who knew his worth, offered him $15.00 per week to make the change. Howard's home conditions were such that he did not want to leave, and asked for an additional 25 cents per day, and was refused. Well, Howard left, and a draftsman was employed at $3.00 per day, and after spending nearly a week trying to lay out a train of clock gears without success, he was discharged, and another man filled his place. This new man lasted about two weeks, and he was not even competent at drafting plain tools, but he was paid $3.50 per day, and would have had steady work if he had been one-half as competent as Howard.

Still another, and a more convincing argument, was brought to the superintendent's attention, which was directly opposite to his statements a moment before. There was in the tool-room a man that was given a week's notice by his foreman to look up another job, as his work was not satisfactory, and in the mean time this same superintendent placed him foreman of a department at 50 cents per day more than he was receiving in the tool-room, and 25 cents per day more than the best paid tool-maker in the room.

A man's ability will carry him just so far to-day, and to continue he must have the "pull." I forgot to mention that this very superintendent was holding his position through a "pull," and to-day he is running a large drill press in Schenectady, and I often wonder if he keeps his belts tight and puts on the coarsest feed now that he is striving to receive a foremanship through his ability. These instances are cited merely to show that it is my opinion that the manufacturers themselves are to blame for boys refusing to take up shop work. My own experience as a manufacturer has been that the more wages the help are allowed to make, the greater the profits and harmony. In nearly every shop where piece work prevails, there is a limit as to the amount that the operator may earn, and if he should exceed this amount he promptly receives a cut. This curtails the production, as I remember well that before learning my trade I worked at piece work, and often my day's pay was earned before noon, and I was obliged to loaf the rest of the day. This I claim is wrong, as it causes ability to lie dormant when a person knows he will receive a cut down if he does all he could. When our piece work prices were set, these conditions were taken into consideration, and a price was set far below that paid in other shops for identical operations, but the help was given to understand that they were at liberty to make all they possibly could without fear of being cut down. The result was that we paid less for the same operations than our competitors, and our help make from 25 to 50 cents per day more than the help in other factories doing exactly the same work. The writer has worked years at the bench, has held numerous offices in I. A. O. M., but in all his experience he fails to find anything in his opinion so detrimental to the manufacturer's interest as to absolutely refuse to pay more than a certain amount. If a man knew that by hard work he could earn $10.00 at the bench, it would be his ambition to reach that price if possible. In the meantime the company would receive the benefit of his increased energies, whereas, on the other hand, if he is receiving all that the company will pay, the company is receiving about four hours actual work, three hours government work, two hours "soldiering," and a lot of discontent.

NOVEL IDEAS IN DIE MAKING.

About seven years ago, what is now the Providence Mfg. & Tool Co. of Providence, R. I., began the manufacture of a mechanical accountant, the invention of Mr. Turck, the present superintendent of the shop. Mr. Turck's experience, so far as shop work and tool design is concerned, had not lain in the direction of die-making, so in equipping the new plant for the manufacture of the accounting machine he was at first hampered by his lack of knowledge on this subject. The die work required was of a high order. The construction of machines of this type is often such that errors are cumulative. Several similar parts are used, attached to each other in series, for instance, in such a way that if the holes by which they are riveted to each other are slightly wrong in their dimensions, the error will be multiplied by the number of parts. The machine depends for its operation quite largely on the action of pawls upon fine ratchet teeth, and on the meshing of fine pitched gears and toothed segments with each other. The effect of cumulative errors in such circumstances would be to throw these fine pitched ratchets and gears out of step, and make the operation of the machine impossible. Long leverages are also a disturbing factor. When a long, slender member is located by two rivet holes close together, it takes careful work in punching those rivet holes to bring the parts into alignment.

In Providence, when die-making is mentioned without any qualifying explanations, the making of press tools for the jewelry trade is meant, Providence being one of the greatest centers in the world for this business. On this account, when the superintendent of the new shop hired die-makers, or let die-making out to men who made a business of that class of work, he found that the work returned to him was performed in accordance with the jewelry die-maker's standards of accuracy, which were far below those required in the interchangeable manufacture of machinery of the kind he was building.

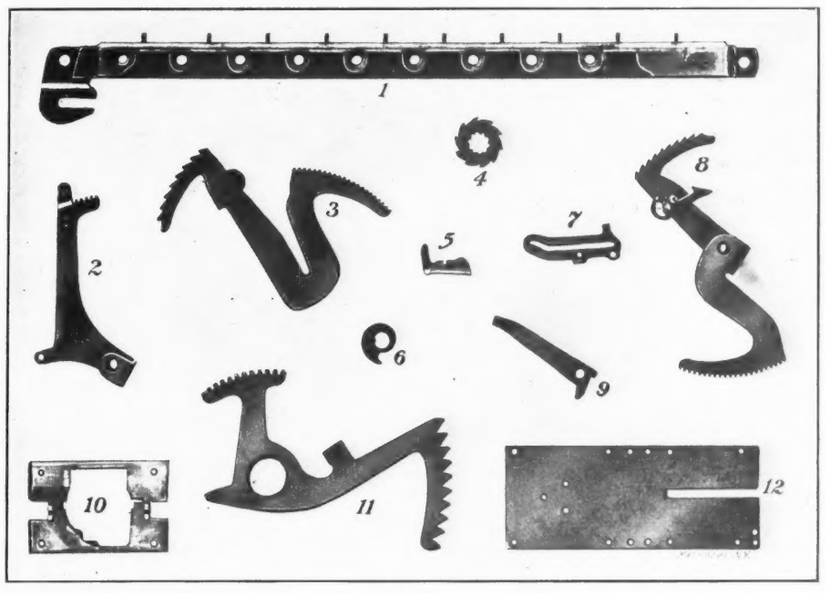

Fig. 1. Some Examples of Good Press Work.

Meeting with this difficulty in finding workmen or firms able to do his work, and being hard pressed for time, he determined, inexperienced though he was, to make a brave attempt to do the work himself, with the help of such skilled machinists as he could hire in a city where skilled machinists are not at all uncommon. The results obtained were satisfactory and even surprising, as in many other cases where men have been forced to work out for themselves the details of a business about which there is supposed to be more or less mystery. As might be expected, however, some of the methods followed are original and unusual. This article is devoted to such of these unusual and original methods as were noted by the writer in a half-day's visit.

In the halftone in Fig. 1 are shown a number of press-made parts. Some of these are interesting in themselves, while others are remarkable principally for the methods used in producing them. Part No. 12, for instance, is a very simple piece, but the punch and die used in piercing the holes, while not unusual so far as surface appearances go, will serve well to illustrate some of the original practices of this shop. This punch and die, shown in Fig. 2, perform the simple operation of punching the nineteen small holes in the blank, which is located over die *A* by the carefully fitted aperture in jacket *B*. The punch is composed of a body *C*, a cast iron holding plate *D* in which the small punches *E* are driven, a stripping plate *F*, held as shown, and forced outward by the compressed rectangular ring *G* of rubber behind it.

The Construction of a Piercing Punch with a Novel Stripping Plate.

The making of this punch and die follows, in general, the order given below. Stripper *F* is first made of tool steel. The holes for the dowels *H* are next drilled. Then the holes through which punches *E* pass are laid out from model or drawing, as the case may require, and drilled to a *larger* diameter than the punches which are to pass through them. After these holes have been drilled, the plate is hardened and ground and the holes for the punches are filled up again by driving into them plugs of tool steel wire, of suitable size. The location of these holes is now laid out again on plate *F*, and this time very carefully; then they are finished to the exact size or slightly below if they are to be lapped. Since the body of the plate is hard, it cannot cave in or wear as it would if left soft. A full bearing on the stock to be blanked is absolutely necessary if the work is to be well done. The plugs allow the plunger holes to be located after the hardening of plate *F*, thereby preventing displacement from the heat treatment. To the stripper plate are now riveted the four dowels *H*, which enter holes in the stripper rim or "collet" *J*, and locate the plate. Small round-headed setscrews *K* bear on pins *H* and hold *F* and *J* together. Punch holder *D*, of cast iron, is machined to fit closely in collet *J*, and the holes for the punches are transferred to it from stripper plate *F*. The punches *E*, made of tool steel wire, are now driven into the holder, headed over at the back side, and ground flush. The punches may then be hardened in the usual manner. Before being assembled on the punch body *C* with the rubber spring *G*, a hardened steel backing *K* is inserted between *D* and *C* to take the thrust of the hardened punches.

The rubber spring *G* is cut from sheet stock and may be made either from separate strips built up on each of the four sides of the punch, or from rectangular rings, if that can be done without wasting the stock. Screws *L* are adjusted to bring the face of the stripper flush with the faces of the punches, after which headless setscrews *M* are screwed in to make the adjustment permanent. Screws *L* may then be taken out and replaced without losing the adjustment. The punch holder *D* and pad *K* are held to the holder by screws *N* and dowels *O*.

A Piercing Die with Inserted Tool Steel Plugs for Cutting Edges.

The body *A* of the die is made of soft steel or cast iron. In this body are driven standard taper plugs of tool steel of suitable size, and so arranged as to be in position to furnish a tool steel material for all the actual cutting surfaces of the die. In the case shown in Fig. 2, nine of these plugs are used, carrying from one to three holes each. In making the recesses for these plugs standard tools are used. The seats are first

drilled nearly to size, and then finished with a tapered end mill or counterbore, which is kept carefully ground to the proper dimensions, so that when the plug is driven in until it binds tightly on the taper, it will also seat on the bottom. These various plugs *P* are prevented from turning in the holes by dowel pins *Q*, in most cases, or where the plugs run into each other (as shown in two cases in the die here described) by the interlocking of the flat abutting surfaces. These precautions make it possible to remove the plugs at any time and return them accurately to their original positions.

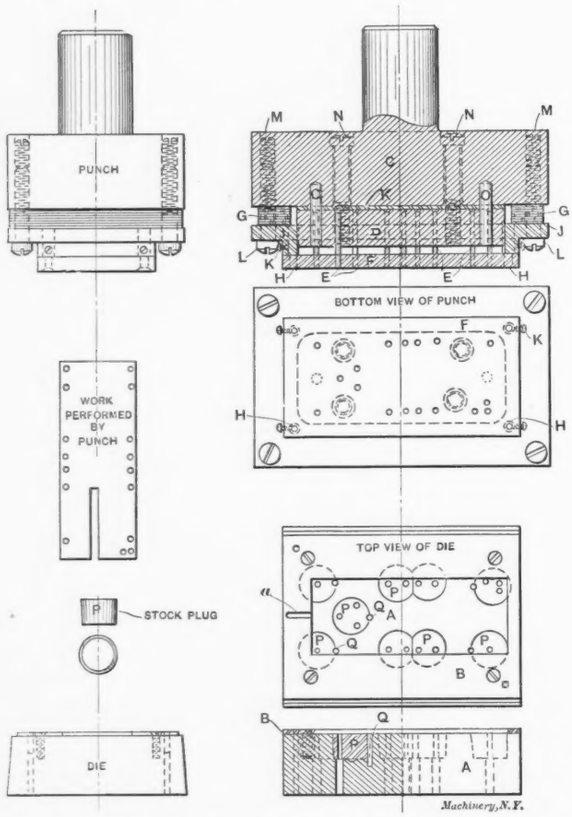

Fig. 2. A Piercing Punch and Die involving some Original Ideas.

The die plate *A* having been fitted with its plugs as described, the holes in stripper plate *F* are now transferred to it by any suitable means, all these holes being received in the tool steel plugs as explained. The plugs may now be removed, to be hardened and lapped separately. The clearance holes for the scrap are drilled, and the plugs are returned to their proper places. The jacket *B*, which locates the blank on the die, may, if desired, be punched from stock of suitable thickness by the blanking die used for making the blank to be operated on in this piercing die. The edges of the opening are then merely filed enough to allow the work to enter and be withdrawn easily. A slanting groove, as shown at *a*, is cut with a round file into the jacket at one end to permit the insertion of a pick or awl to remove the work.

The points of interest in this die are: The rubber-backed stripper plate; the use of a soft stripper plate bushed in the manner described with hardened tool steel; and the insertion of plugs of tool steel in a soft die block to form the cutting edges of the die.

The rubber spring has proven very satisfactory. It will last for a number of years in dies having ordinary use, if it is not exposed to oil and other deteriorating influences. Being in the upper member, there is little likelihood of its being spoiled in this way. The use of this stiffly spring-supported stripper plate gives a punch and die of the design shown all the advantages of a sub-press, so far as concerns the ability to punch small holes in thick material and leave thin walls of metal between open spaces in the punching. As evidence of the ability to do work of this kind with a punch and die of the style just described, parts 7 and 10 in Fig. 1 may be particularly noted. Here the holes are considerably smaller in diameter than the thickness of the stock, and the internal spaces have been punched so close to the edge, in places, that the remaining section is narrower than it is thick.

The method of bushing the stripper plate by drilling the holes large originally, plugging them with tool steel wire after hardening, and redrilling them to the proper size, makes it possible to harden the surfaces in contact with the work, without distortion of the dimensions between the holes. Plates of large size, even, are made in this way.

The advantage claimed for the method by which the stripper plate is made, may also be claimed for the use of hardened plugs in a soft die body, since it is possible to harden these parts individually without changing their location with reference to each other. In addition, both of these schemes allow changes to be made in the dies with a minimum of trouble and expense. If it is desired to change the location of a hole in the die, the old plug may be removed and a new one inserted. In the same manner new holes may be drilled in the stripper plate in which new tool steel wire plugs may be driven for new guiding holes for the punches, although the change is limited by the size of the plugs. This consideration is of considerable importance if the parts manufactured are subject to improvement from time to time. This provision reduces the expense of spoiled work as well, since it is not necessary to throw away an expensive press tool if one or two of the holes are wrongly located.

Rubber-backed vs. Sub-press Dies.

It will be noted that part No. 12 in Fig. 1 (for which the punch and die just described were designed) is made in three operations. Under ordinary conditions, it is the belief of Mr. Turck that this procedure is preferable to the use of the sub-press. The rubber spring supported stripper plate, as just described, gives all the advantages of the sub-press, so far as ability to do fine work on thick stock is concerned. Slender punches are supported by the stripper in the same way as with the sub-press; the rubber spring holds the stripper so firmly on the work that the distortion of thin stock is prevented. The sub-press certainly has the advantage of ease of setting in the machine, since it is not necessary to carefully line up the punch and die, which are in permanent alignment. It is possible, however, that the high initial cost of the sub-press would in many cases more than pay for the extra wages of an experienced and careful man in setting tools up during the lifetime of the punch and die. It must also be admitted that work cannot be done as rapidly with the three sets of tools necessary for making the piece in the manner here described, as would be possible if a sub-press were used. The saving in first cost, however, and in the cost of subsequent operations, is believed to be sufficient in the case of the Providence Mfg. & Tool Co. to show a balance on the right side of the sheet for the simpler form of press tool. It should be said in this connection that this firm freely makes and uses the sub-press die, both for customers and for their own work.

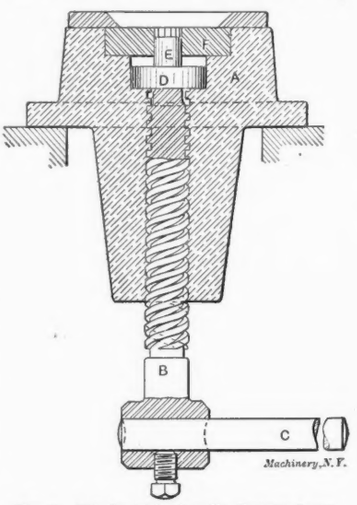

Fig. 3. Die for Bringing Up Drawn-down Corners.

The Thickening of Corners Drawn Out in Blanking.

An operation that interested the writer was a coining process used for reshaping the points of gears, ratchets, etc.—such parts, for instance, as are shown in samples 4 and 6. In such a piece as No. 4, whatever the design of the die, the blank produced will be found to have the points drawn down

thinner than the stock thickness. To bring the part back to uniform thickness with sharp points, the device shown in Fig. 3 is used. Here we have an attachment to a hand screw

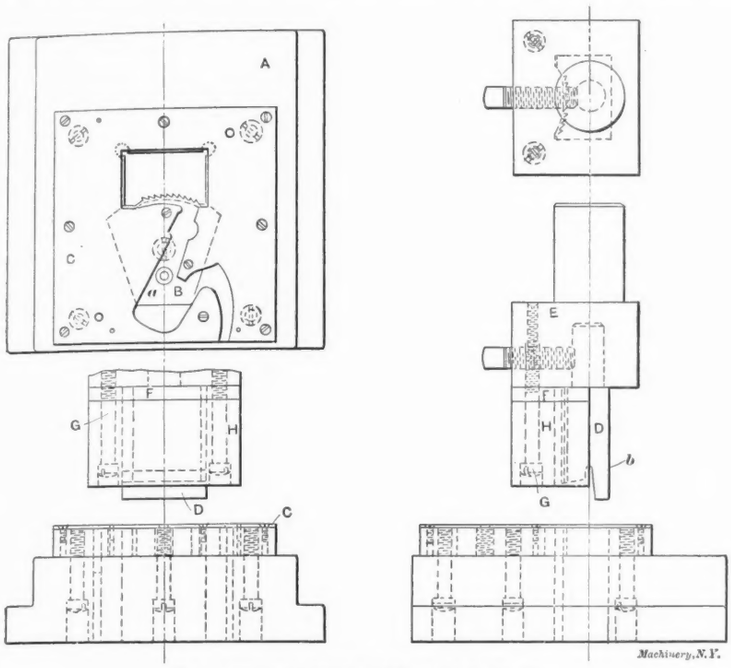

Fig. 4. Example of Type of Die used for Shaving.

press. The body *A* is fastened to the bed of the press. The screw *B* projects through the bed and carries at its lower end a handle *C*, which is adjusted to one side or the other to bring it in position to be swung by the foot of the operator. In a counterbore in body *A* is seated the plug *D* and the ejector *E*. *D* and *E* are forced upward by the action of screw *B*. At *F* is a die, given the shape desired for the outline of the finished part; it is slightly enlarged, however, for a short distance at its upper end. The part as it leaves the blanking press is purposely made a little large in outline at the points where the thinning occurs, due to the drawing out of the stock. When the piece is inserted by the operator in the upper end of this tapering die, the extra metal thus provided is forced inward to thicken the points to the required amount as the punch is brought down upon the work by the hand of the operator. When the piece has been forced to the bottom, it is clamped between the plane surfaces of ejector *E* and the punch above it (not shown), and the metal is forced to flow to that part of the blank where it is most needed. The result is a flat ratchet with plane faces and uniform thickness. It will be understood, of course, that during this coining operation ejector *E* and plug *D* seat in the counterbore in body *A*, screw *B* being lowered out of contact. A push of the operator's foot on handle *C* brings the ejector up again until the piece is

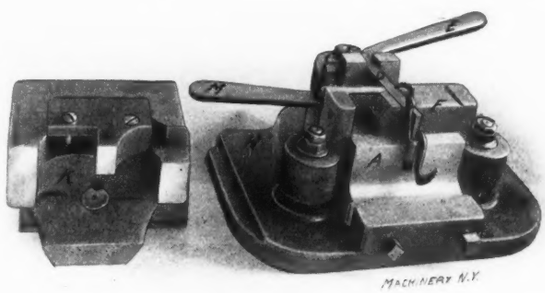

Fig. 5. Bending Attachment with Removable Die. Operation Completed.

forced out of the die. The thread of the screw is of such a steep pitch that it will return again by its own weight.

The comparative slowness of operation resulting from the use of a hand and foot power press and hand feeding is, in a measure, characteristic of the shop. It is the belief of the superintendent that better results can be obtained at times by methods like that shown than by more "modern" ones. The aim is, through careful workmanship and careful inspection, to have the parts so nearly right when assembling time comes, that no fitting will need to be done in the assembled machines. No fitting is, in fact, allowed. Certainly the method described for striking up the corners of these ratchets is a much less dangerous one than would be the case if a power press were used, so the idea has its advantages, so far as safety is concerned, at least.

A Typical Shaving Die.

In such parts as are shown at 3 and 11 in Fig. 1, the ratchet teeth and gear teeth are only roughed out in the blanking die, being finished by a second cut or "shaving" process. A typical die and punch for this operation are shown in Fig. 4. Here, as in Fig. 2, the work is held by a rubber spring backing while the punch is at work. The die is made of a soft body *A*, in which is inserted the hardened piece *B* carrying the cutting edges which are to form the ratchet teeth on the work. This piece *B* has its teeth cut on it in the milling machine, the hole at *a* serving to center the piece for this operation. This gives assurance that the teeth will be properly spaced and cut accurately to the proper radius. A rectangular opening with carefully machined sides is made through the die block *A*. Into this opening the toothed cutting edges of piece *B* project. As in Fig. 2 a "jacket" *C* is provided for locating the work over the cutting die. The punch *D* is set into a holder *E*, which in turn is fastened in the ram of the

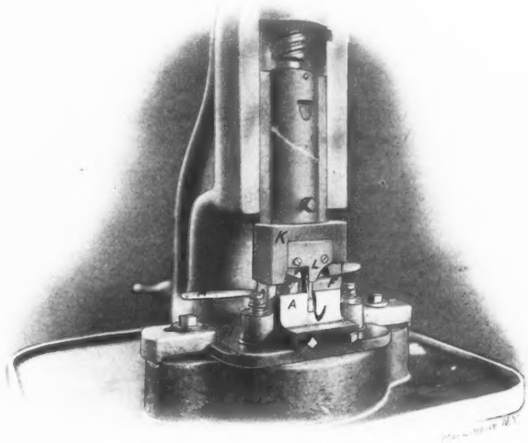

Fig. 6. Bending Device in use in Screw Press.

machine. A projecting guiding surface, *b*, on the punch, enters the rectangular opening in the die and bears against it on the back and sides. This keeps the cutting surface of the punch up to its work against the cutting edge of the die. As shown, the cutting edge of the punch is beveled. This gives a slight top rake to the edge and produces a shearing cut as well, the outer corners coming into action before the center of the outline reaches the stock. The rubber spring backing at *F* is held by screw *G* between the pressure block *H* and the punch holder *E*. It performs the same functions at the stripper plate in the other die.

Bending Punchings to Provide Double Bearings.

It will be noticed that samples 1, 5 and 8 in Fig. 1 have been made on the principle of bending the punchings to give a double bearing at pivotal points, the long bearing insuring lateral steadiness of the part without making it necessary to resort to the use of castings with long hubs. This principle is carried out throughout the calculating machine which is this firm's principal product. In some cases, especially where the pivot holes are punched previous to bending, as is the case

in sample 8, very accurate work must be done in the bending to bring the part to exactly the right form. In the sample referred to, for instance, the ratchet teeth on one side and the gear teeth on the other must bear a definite relation to each other, and to the axis about which the part rotates. The bending tools by which the forming operation is performed for this part are shown in the halftones in Figs. 5 and 6 and the line cut Fig. 7. Referring to Fig. 7, the blank for part 8 (shown at No. 3 in Fig. 1 before the piercing of the pivot holes) is laid on top of former *A*, where it is located by the pins *B B* which enter the pivot holes. In this position the part lies between the fixed jaw *C* and the movable jaw *D*, which are then clamped together on the blank by bringing handle *E* to the position shown, where its wedge-shaped cam surface *b* has entered between the long ends of the jaws *D* and *C*, and brought the outer ends together. The jaws *D* and *C* and lever *E* are all attached to the holder *F*, which is a sliding fit on three vertical posts *G*, fast to the base *H* of the fixture. Slide *F* is held to the upper extreme of its travel against the lock nuts and washers at the top of posts *G* by spiral springs *J* at each post. These parts are shown to good advantage in the halftone, Fig. 5. *K* is a plunger mounted in the ram of the press. It bears on finished projections on slide *F* at three points as shown, while the hardened part *L* bears on the top of lever *D*, directly over the work. When *K* and *L* strike slide *F* and lever *D* in their descent, they carry with it the slide and its attached levers, and the work as well, against the slight resistance of springs *J*. The work grasped between the levers is thus carried down through the opening in die *A*. This action serves to bend the part to the form desired. Fig. 6 shows the operation completed. As shown, this work is done in a hand screw press. This is another example of manufacturing methods which at first sight seem rather crude, but which have proven, in the opinion of the superintendent of the shop, to be most satisfactory, his contention of greater accuracy and more uniform results from such methods applying particularly in the case of forming operations of this kind.

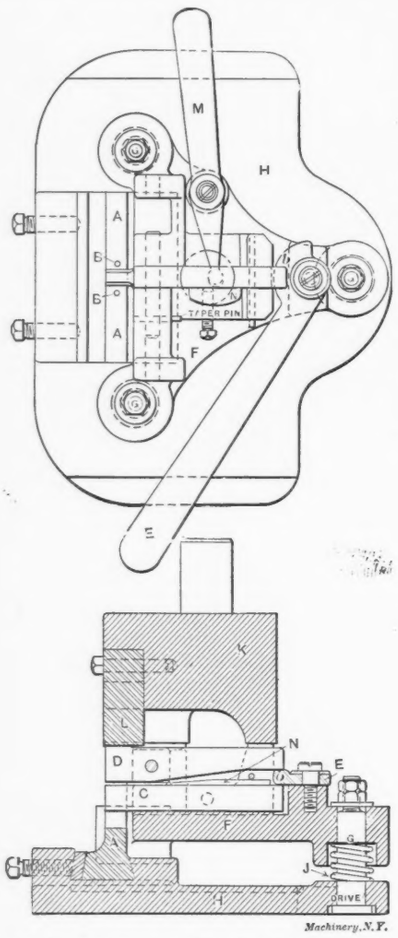

Fig. 7. Construction of Bending Attachment.

The piece is ejected from the tool at the completion of the bending by lever *M*, which thrusts forward the ejector *N*. This ejector is at its working end slightly less in thickness than the stock of the punching operated on, and is thus able to enter freely between the jaws and eject the work. In this tool, members *A*, *C* and *D* are changed for different parts, the rest of the structure being the same and serving for a number of different operations.

A Die for Double Punching.

In the case just described, where double bearings occur, the holes are punched before bending. This is not always the case, however. In samples 1 and 5 in Fig. 1, the parts were first bent and then punched, the operation being performed in a very interesting way. The punch descends and makes the hole in the upper thickness of the stock. Continuing through an intermediate die, and carrying before it the punched-out stock, it arrives at the second or lower thickness of stock. The continued movement of the punch then presses the little plug of punched-out metal through the lower thickness of stock, and this forms the second hole. Strange to say, it has been found in practice that this second hole is generally the better one of the two, even though it is made with a soft plug of steel instead of with a hardened punch.

The line cut Fig. 8 and the halftone Fig. 9 show the double punching tools used in making the pivot holes in sample 1, Fig. 1. This, it will be seen, is a progressive operation, all the parts in the lot being punched for one of the holes, after which the die is altered and the next hole in order is punched in all of the parts—and so on. The piece to be operated on is located lengthwise by slipping it over a gage pin in sliding block *A*, which may be adjusted to any position on slide *B* to suit the hole it is desired to punch at the time. Being located on block *A* in the manner described, it is swung around until the intermediate die *C* enters the channel formed by the two sides of the work. Cam lever *D* is then swung to the position shown in the line cut, where it has brought clamp lever *E* against the stock, holding it firmly in position for the operation. The punch *F* is a simple turned piece of hardened steel, held by taper pin in punch holder *G*. It is surrounded by a stripper *H* which is screwed to a holder *J*, backed by the usual rubber spring at *K*. This serves to hold the work firmly during the operation, and strip the work from the punch when it returns to its upward position. As before described, the punch in its descent breaks through the upper thickness of stock, carries the plug of soft metal thus formed before it until it comes in contact with the lower thickness, where it forces the plug through and forms the lower hole. It will be noticed that intermediate die *C*, though held firmly so far as displacement horizontally in any direction is concerned, is yet provided with a rocking face where it bears on the body of the die *L*. This arrangement takes the strain of the punching from the slender intermediate die, which is thus bent downward until it is firmly supported by the stock of the part being worked on beneath it. For removing the work after the operation, an ejector *M* is provided, with a handle *N*, which operates in a way which will be easily understood from an inspection of Fig. 9. It is not shown in Fig. 8, having been added at a date later than the drawing from which this cut was made.

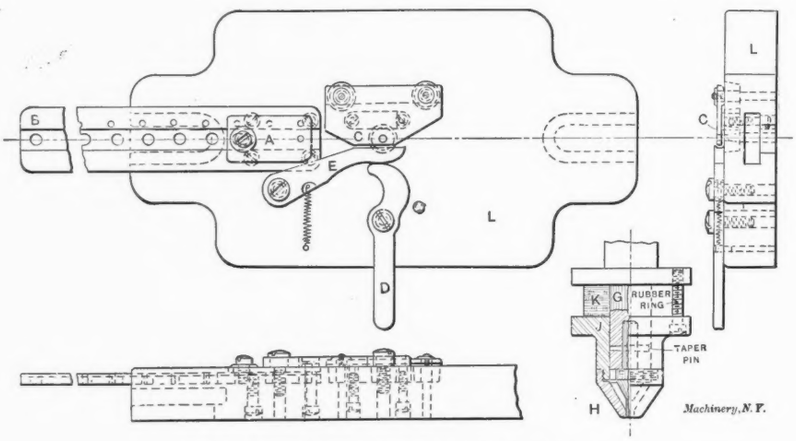

Fig. 8. Construction of Die for Double Punching.

Practice in Hardening Punches, Etc.

Blanking punches are hardened in this shop in a way that is originated here and not practiced elsewhere, so far as the writer is aware. After the plunger of a blanking die has been cut into the female portion of the die, and finished ready for hardening, it is placed in the fire and brought to a slightly lower heat than ordinarily used for hardening clear through. Cyanide is then deposited on the parts of the tool to be hardened—that is, on the periphery of the cutting edge. It is allowed to "soak in," it sometimes being necessary to apply cyanide two or three times, depending on the size and bulk of the plunger. It is then again brought to the proper heat, which should be a little lower than is ordinarily used for hardening clear through. Then it is quenched in oil. With

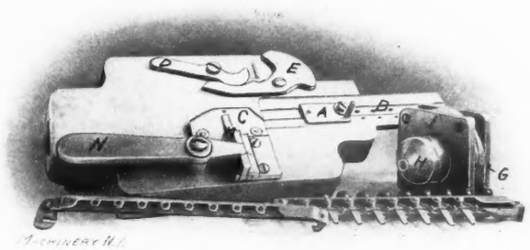

Fig. 9. Double Punching Die shown in Fig. 8.

large and bulky pieces it is first necessary to immerse the work in water as a preliminary cooling operation. This immersion should merely be a dash into the water and out again, after which the piece is put into the oil until cooled.

It is to be understood that this cyanide-hardened punch is made of tool steel of the ordinary grades used for punches. The treatment is such that only the exterior skin is hardened, where the cutting action takes place as the edge is ground down from time to time; the rest remains soft and strong, able to withstand very hard usage. But the great advantage is that the parts are not drawn out of shape by this heat treatment, since only a very small portion of the metal is hardened.

It is not feasible to use this cyanide process for hardening female dies for purposes other than blanking soft brass parts. As the blanks are pushed into the die, there is a swaging process taking place which would force the walls out if they were case-hardened; it is therefore necessary to harden clear through. Where the outlines are intricate and delicate, however, the shrinkage is so small that in most cases there would be no necessity for this. In any event the plunger or punch would be made whole, and cut into the die. The plunger would then be hardened by the cyanide process, and would not be thrown out of shape, but would drop through the die as nicely as before the heat treatment. It is thus seldom, if ever, necessary to make the plunger in sections.

As remarked at the outset, the novel points in die making practice to be seen at this shop are to be explained by the fact that the methods used there are the result of studying the problem of die-making from original experience, without much to build on in the way of second-hand knowledge, or traditions of others. The workmen here have been educated in tool-making in the shop itself, and few of the better ones, at least, were tool-makers at the time they came. This is evidently another example of the truth that it is possible for determined and intelligent men to start out in an unknown field in the study of subjects about which there is popularly supposed to be something of mystery, and still do things worth while, and even be able to add something original of value to the practice of the art. As evidence of this firm's success, it may be said that a large and increasing part of its business consists in the design and construction of dies and special tools for other manufacturers. R. E. F.

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Do not wrap paper around an incandescent electric lamp for a shade. A fire might easily be started from the heat

THE CARD INDEX IN THE JOBBING SHOP.*

J. S. WATTS.†

The writer has charge of a shop doing a general line of repair work and some building of new machinery, in a place where there is little scope to take up any standard line of work or even to make the same machine twice without alteration. To avoid endless confusion he has found it necessary to evolve some system of keeping records of the machines and parts of machines sent out, and has written this article describing the system, in the hope that it may prove useful to some other superintendent in a like position.

In most shops of this kind a part of the work is done to blue-prints or sketches supplied by the customer, and part to drawings made by the firm's own staff; and the patterns are sometimes the customer's property and sometimes the firm's. The remainder of the work is repairs, overhauling, refitting, etc., of which no record need be kept. The problem resolves itself into these requirements: First, to be able to find at any time the drawing to which any part of any machine was made, given the customer's name. Second, to have a complete index to all patterns, drawings, foreign blue-prints, etc., to save duplication of any of these where they can be worked in on another order.

On receipt of an order from a customer it is written out on a form, a copy of which goes to the drawing office, pattern shop, boiler shop and machine shop, or such of these departments as have work to do on that order.

We will suppose that this order is for a machine to be made to the firm's own drawings. The drawing office then, on receipt of this order, makes out a production sheet on bond paper forms, giving name and number required of each part, drawing number, pattern number if a casting, and material of which it is made. This production sheet should include everything required, bolts, nuts, oil-cups, gaskets, split pins, nameplate and every detail, no matter how small. In the case of forgings it should give in addition to drawing number, the length and size of bar required to make it. The required number of prints should then be made from the production sheet,

NAME BROWN & Co -

ORDER NO.	NAME OF MACHINE	SIZE	HAND	MACHINE NO.	DWG. NO.
1137 '06.	HORIZONTAL ENGINE	12×12	L-H.	231.	52-A.
1678 '06.	HOIST - ELECTRIC	200 HP	R-H	273.	12-A.
182 '07.	BOILER-HORIZONTAL RT.	48×12'-0"	—"—	325.	46-A.
3746 '07.	—"— VERTICAL MARINE	42"×7'-0"	L-H	700.	722-A.
627 '07.	SPLIT PULLEY	66"×27"		1172.	7237-B.
233 '07.	ROPE PULLEY & SHAFT	12'-0"		926.	1023-C.
3681 '07.	PORTABLE BOILER	48"×14'-0	R-H	7280.	61-F.
3875 '07.	BOILER-SCOTCH	8'-6"×10'-3"	—"—	2122.	72-F.

Fig. 1.

and the order number, name of customer, date issued and number of machines required (the production sheet should always be made out for one machine only) put on the prints and not on the original as this may be used again later, on other orders. One print should then be sent to the stores department, to order the material from, and one to each of the different departments having work to do on that order, the pattern shop having to issue the patterns and orders to the foundry department. Also one print should be filed away as a record under the order number, preferably in an envelope, together with any special specification or other matter referring to that order only; these will be kept in numerical order and should be stored in a fireproof room, but, in a convenient place for reference. The original could now be altered to suit any future orders or improvements in design without affecting our record of that order. Any alterations to the drawings for

* For previous articles on shop card index systems see MACHINERY, November, 1903, The Card Index in the Drafting Room; September, 1905, Index System.

† Superintendent of I. Matheson & Co., Ltd., New Glasgow, Nova Scotia.

subsequent orders are made in such a way that we have a record of the original dimensions. However, this matter is outside the scope of this article.

Now to duplicate any part of an old order, we have a card index of the production sheet prints that are filed under their order numbers. These cards are indexed alphabetically under the customer's name; a copy of the card is shown in Fig. 1.

P.S. NO.	DESCRIPTION	ASSEMBLY DWG. NO.
51.	BOILER-VERTICAL - 39"x5'-9" - 200 LBS	55A.
52.	" " - 40"x5'-6" - 125 "	20A.
21.	" " - 42"x7'-0" - 90 "	10A.
5.	" " - —"x6'-1" - 125 "	15A.
17.	" " - 46"x7'-0" - 100 "	10A.
46.	" " - 52"x8'-0" - 150 "	49A.
4.	" " - 60"x9'-0" - 160 "	76A.
33.	" " - 72"x10'-0" - 140 "	30A.
49.	" " - 78"x—" - 150 "	53A.

Fig. 2.

This card is filled out for each order for that firm and filed away in the index cabinet. Therefore, given the customer's name, we can by consulting this index find the order number under which his machine was built, and by getting out the production sheet print for that order number we get the drawing numbers we require.

The columns for size and hand save us the necessity of looking up two or three production sheet prints, as for instance if we get an order for a set of grate bars, same as supplied by us, with a 48-inch boiler, for Brown & Co., we look under Brown for Brown & Co.'s card, and then down that card till we come to a 48-inch boiler, which will give us the order number, and from the production sheet print for that order number we can get the pattern number and number required. If we had not the size on the card we might have any number of boilers built by us for that firm to look up in the production sheet prints before we found the 48-inch size.

The Machine No. column is used in case a customer sells his machine to some one else, the number being stamped on the name-plate of the machine.

The Drawing No. column gives the assembly drawing number, and may save time if one wanted only an assembly drawing, but it is primarily intended for orders such as stacks, smoke connections, etc., which only require one drawing. No production sheet is made for such orders, a bill of material on the drawing giving all information required.

DWG. NO.	DESCRIPTION
701-B	ROPE PULLEY - 1'-4"
402-B	" " - 6'-0" - 2 15/16" BORE.
1-C	" " - " - 3 7/16" "
111-B	" " - " - 4" "
1-C	" " - " - 4 5/8" "
103-B	" " - " - 6" "
12-C	" " - 12'-0" - 1 1/4" ROPE.
23-C	" " - " - 1 5/8" "

Fig. 3.

The original production sheets have a card index with alphabetical guide cards, and are indexed under the name of the machine, as boiler under B. A copy of these cards is shown in Fig. 2. The production sheets are numbered in order, as made. Our own drawings are indexed alphabetically under the name of the part. These drawings are numbered and filed consecutively as made, and are given the suffix A or B. A is the large size (18 x 24-inch) and B the small size (9 x 12-inch). The A and B drawings are numbered and filed independently of each other. The cards for indexing these drawings are shown in Fig. 3. Each part of a machine is on a separate card, and the cards are re-written from time to time to keep the parts on the card in order of size, smallest size at top, as other similar parts of different sizes are made and interpolated.

If the order should be to make a machine to the customer's blue-prints we number these prints consecutively, starting with the number after that given to the last blue-print on the previous order, and giving it the suffix *C* or *D*, as 125-*C*. The suffix *C* indicates that the patterns shown on that print are our property, and the suffix *D* indicates the reverse. These prints are folded and put in envelopes bearing the same number, and are filed away in consecutive order, the *C* and *D* prints being in separate drawers. The *C* prints are indexed with our own *A* and *B* drawings, so that we have on the cards a complete list of all sizes of patterns or designs we have of that particular part. The *D* prints are indexed under the name of the part, the card being shown on Fig. 4. The column for print number is for the number given the print by the customer, and Name of Firm is the name of the customer or owner of the print; these two columns are for purposes of ready identification.

NO.	NAME OF FIRM	DESCRIPTION	PRINT NO.
36-D.	LONDONDERRY I.&M.Co.	STACK - 1'-10"	48.
39-D.	MABOU & GULF COAL CO	" - 3'-0"	50.
35-D.	ACADIA COAL Co	" - 3'-4"x50'-0"	72.
38-D.	MABOU & GULF COAL CO.	" - —"x60'-0"	71.
82-D.	JOHN BLACKLOCK & Co.	" - 3'-6"x65'-0"	84.
91-D.	A. GARRETT & CO.	" - 4'-0"x70'-0"	97.
42-D.	B.A. MARTIN MACHINE CO	" - 4'-6"x75'-0"	195.
450.	NOVA SCOTIA STEEL & COAL	" - 5'-0"x80'-0	372.
700.	U.S. STEEL CORP^{n}.	" - 5'-6"x85'-0"	170.

Fig. 4.

The foregoing is only a bare outline of the system, but it will be sufficient to show its cheapness and adaptability to the work required of it.

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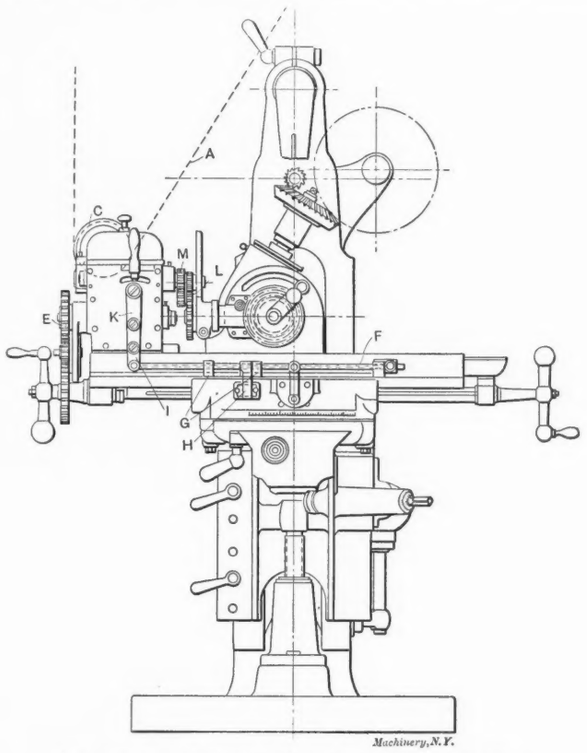
TO IMPROVE IGNITION IN COMBUSTION MOTORS

A weakness of the internal combustion motor is the ignition, and although the changes of design in recent years have greatly improved this feature there is still much to be desired. Electric ignition of the jump spark type has generally displaced the make-and-break form, which in turn succeeded the hot tube. But the jump spark has a high voltage and requires the very best insulation. Recent investigations of the causes for failure of electric ignition have resulted in some interesting disclosures. It was demonstrated that a spark plug insulated with porcelain might cause failure, when highly heated, by the electric current leaking across the insulation. The principle of the Nernst lamp depends upon the fact that porcelain at ordinary temperatures is an excellent non-conductor of electricity, but when heated red hot the resistance drops to less than one-thousandth of the cold resistance, and the same condition apparently exists sometimes in the spark plug of the gasoline engine. One means of overcoming this defect is the introduction of an external spark gap as well, as this tends to prevent leakage across the porcelain when the latter becomes highly heated. When the timer makes contact, the rush of current will be sufficient to cause a spark between the internal points, notwithstanding the increased conductivity of the porcelain. It is suggested that trouble of this order might be avoided by more care being taken to keep the ignition plugs cool by judicious arrangement of the cooling water circulation.

AUTOMATIC INDEXING AND FEED ATTACHMENT FOR THE MILLING MACHINE.

As another indication of the activity of European machine tool builders in the matter of designing new machinery and attachments, we present herewith a line cut and description of an ingenious milling machine attachment recently developed by Ludwig Loewe & Co., of Berlin, Germany. The device is intended to be attached to the table of the makers' regular line of universal milling machines. Used in connection with the index head, it feeds the table forward at a suitable rate for a cutting feed, withdraws it with a quick return ratio of 8 to 1, indexes the work, feeds it forward again—and so on. In effect, it makes of the universal milling machine an automatic gear cutter for either spur or bevel gears.

The device consists of an attachment mounted at that end of the table usually occupied by the spiral head. It is driven from a special pulley on the countershaft, provided with an idler for taking up slack in the belt, and thus allowing the table to be moved to any convenient position without slackening the drive. This attachment is connected to the feed screw



Automatic Gear Cutting Attachment for the Milling Machine.

of the milling machine by change gears *E*, which are selected to give the desired feed. Being connected in this way, the usual feed motion of the machine cannot be used. The attachment is also connected to the spiral head by change gears *M*, which are selected to give the required indexing for the number of teeth desired. Lever *K* operates the feeding, reversing and indexing mechanisms. This lever is shifted automatically by adjustable dogs *G*, which strike stop *H*, at the limits of the movement of the table in either direction. These dogs are clamped to rod *F*, which in turn is pivoted at *I* at the lower end of lever *K*. With the machine properly adjusted, the work will be fed forward slowly until the rear dog *G* strikes the stop, when the shifting of the lever *K* thus brought about will reverse the mechanism and rapidly return to its starting position, determined by the striking of the other dog against the stop. The indexing then takes place, and the forward feed is started again. To avoid lost motion and unnecessary mechanism, the usual index plate and crank may be replaced with a device which clamps together the plate and index worm spindles.

The attachment is intended for such work as spur gears, bevel gears, and similar parts which do not require that the work itself revolve while the cut is being taken. The device can be reversed so that the direction of the forward feed and quick return will be changed, in which case the cutter may be run left- as well as right-handed. Special change gears are not necessary, as the regular outfit belonging to the machine can be used. While the attachment was originally designed for machines built by the makers, it can be placed on millers of other makes if they have about the same dimensions for the table and have an index head on the left side. With certain modifications it may be applied to any type of miller.

This device is another evidence of the originality and ingenuity which have characterized recent European machine tool design.

* * *

INDUSTRIAL TESTING LABORATORIES IN GERMANY.

One of the main reasons why Germany has in recent years risen to such a supremacy in engineering matters depends undoubtedly to a great extent upon that there have been established in that country from time to time various testing laboratories maintained at public expense. These investigate technical problems and publish the results so as to thereby benefit the greatest possible number of German manufacturers. While there is no doubt that there has been a great deal of experimental work undertaken in this country, these experiments have, with few exceptions, been carried out by private individuals or firms who have jealously guarded the results of their investigations, regarding them as assets in trade and terming them trade secrets. For this reason the same investigations are often carried on in a large number of different establishments, and considering the nation as a whole, a large amount of work is wasted, inasmuch as if these experiments had been carried on at a general central station, all the various firms would have been equally benefited by the results, with only a fraction of the expense to the nation as a whole. The latest German institution aiming at decreasing the cost of individually conducted experiments is reported to be a large chemical laboratory which will probably be located in the vicinity of Berlin. The initial expense will be $400,000, and the government will probably advance the money needed for keeping the institution working along such lines and in such a way as to give the greatest possible impetus to German chemical industries. The new institution, it is hoped, will work in close cooperation with the factories themselves, and will for industrial purposes supersede the chemical laboratories of the various German universities and colleges, the object of which, it is argued, should be principally educational, and be totally different from that of the contemplated institution which is intended to become the center of chemical research in Germany. It is evident that movements of this kind are far easier to inaugurate in European countries, where there is a strong centralized government considering as its duty to deal with problems of this kind, but there are no doubts that if it would be possible for certain industries in this country to unite and support some kind of a general research laboratory, a great saving would be effected in the long run, and the progress of our industries would be assured in a far greater degree than when individual persons or firms are carrying on their own experiments, often with little or no system.

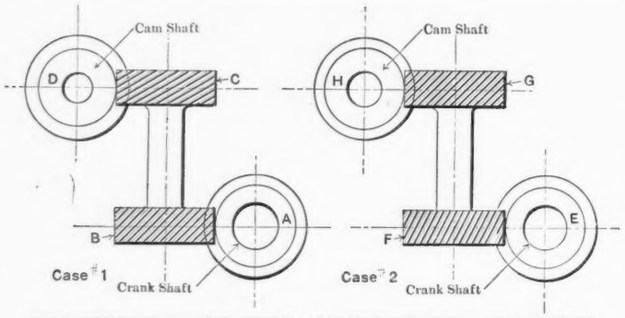
* * *

One of the most noteworthy indications of the supremacy given to military matters in Europe is the common practice on the Continent to have all important railway bridges provided with means for rapid destruction in case of necessity for this in time of war. It seems as if it would be almost discouraging for a designer or builder of such a structure to incorporate such details in his design and work, as will at a moment's notice transform the work of years, as it may be at times, into so much scrap. But this is the price paid for the glory of belonging to a military nation. The works of peace that would have to be sacrificed in a war in the territory of any of the most advanced nations, at the present time, are so tremendous that we can hardly imagine that ever two nations would dare to encounter the loss, if they were to meet on their own territory.

A COMPARISON OF THE EFFICIENCY OF TWO TRAINS OF SPIRAL GEARS.*

A correspondent who signs himself "Minne, England," has sent in the sketches and data shown in Fig. 1. He says, "Here are two different sets of spiral gears for gas engines. In each case the cam shaft runs at half the speed of the crankshaft. I should like to know which is the better arrangement for efficiency and wearing qualities, taking into consideration the nature of the work the drive has to perform, *viz.*, a single cylinder gas engine working on the 'Otto' cycle."

The answering of the question asked by our correspondent involves a little work along the line of resolution of forces and the calculation of efficiency; it is entirely elementary, but interesting nevertheless, as a practical illustration of the



	Angle of Teeth with Axis	Diameter of Pitch Circle	Number of Teeth
A	45°	4"	20
B	45°	4"	20
C	63°-26'	4"	10
D	26°-34'	4"	20

	Angle of Teeth with Axis	Diameter of Pitch Circle	Number of Teeth
E	63°-26'	4"	10
F	26°-34'	4"	20
G	45°	4"	20
H	45°	4"	20

Machinery N.Y.

Fig. 1. The Two Arrangements to be Investigated.

working of well-known principles in mechanics. For the sake, then, of their value as illustrations of the principles involved, these calculations are here given in detail.

Our correspondent asks which of the two arrangements, that in Case 1 or Case 2, is superior in efficiency and wearing qualities. It may be roughly stated that, other things being equal, the more efficient of two mechanisms is the more durable. We will consider this to be true in this case, so will examine the two arrangements for efficiency in the transmission of power. The power losses in the various journals we cannot estimate, because we do not know enough about the arrangement and design of the bearing surfaces. We can easily make an estimate for the power lost in the thrust bearings, and we may also get a comparative idea, at least, of the power lost in the rubbing of the teeth on each other, so to these losses, which are the principal ones, we will confine ourselves.

When two bodies are sliding under pressure, the power lost is equal to the continued product of the normal pressure between the surfaces, the linear velocity of the rubbing, and the coefficient of friction. To estimate the power lost at the various bearing points we are to consider, we have then to estimate these three factors for each case.

We will first estimate the relative bearing pressures at the different places where friction is met with in Case 1. To be logical we will commence our calculations at the driven end of the train of gears, since the forces in the mechanism are due to the resistance offered by the driven members. Fig. 2 is another view of Case 1 as shown in Fig. 1. Gears *A* and *B* make contact on line *Y Z*, which represents the direction of the teeth at the point of contact; *W X* represents the position of the teeth of gears *C* and *D* in contact.

As gear *C* revolves in the direction shown, its teeth, set at the angle of the line *W X*, have a wedging action on those of gear *D* which revolves them in the direction shown. The action and the forces involved can best be understood by referring to Fig. 3. Here *C* is a slide moving upwards. Its beveled edge, representing the tooth surface of gear *C*, forces to the left of the beveled edge on slide *D*, which represents the tooth surface of gear *D*. If slide *D* offers a resistance to this movement, of a magnitude represented by the length of line F_5 in the parallelogram of forces shown, slide *C* will evidently have to exert a force equal to F_3 to overcome this resistance. The resulting normal pressure on the inclined bearing surface of contact will evidently be F_4. The end thrust or pressure against its abutment of slide *D* will be F_3, while that of slide *C* against its abutment will be F_5.

Understanding the method of applying the parallelogram of forces in Fig. 3, we may transfer the construction to gears *C* and *D* in Fig. 2. Having F_5 given, we can find F_4 and F_3 as there shown. F_3 is the tangential pressure at the pitch line required to be given by gear *C* to move the mechanism against the resistance F_5 offered by gear *D*. Since gears *B* and *C* have the same diameter, F_3 must likewise be the tangential pressure applied at the pitch line to gear *B*. Constructing a second parallelogram of forces for gears *A* and *B*, as shown, we find that F_2 is the normal pressure between the faces of the teeth in contact, and F_1 is the tangential force which has to be brought to bear at the pitch line of gear *A* to move the mechanism. Consider that F_5 equals unity (since we are after comparative results only) and measure the other forces to this scale. This can be done fully as well by calculation as by measurement. An elementary knowledge of trigonometry will give us the following results:

$F_5 = 1$

$F_4 = F_5 \div \sin \alpha_c = 1 \div 0.894 = 1.118$

$F_3 = F_5 \times \tan \alpha_d = 1 \times 0.500 = 0.500$

$F_2 = F_3 \div \sin \alpha_a = 0.500 \div 0.707 = 0.707$

$F_1 = F_3 \times \tan \alpha_b = 0.500 \times 1.000 = 0.500.$

We have next to find the rubbing velocities of the various bearing points. Fig. 4 will assist us in this. Here we have the same slides *C* and *D*, representing gears *C* and *D* in Fig. 2 or Fig. 5. If we consider that slide *C* is moved upward at a uniform velocity, in a unit of time it will traverse a distance equal to V_3, moving from position *g h* to *g'h'*. This evidently forces slide *D* to the left at a uniform velocity, moving it in a unit of time from *e f* to *e'f'*, a distance measured by dimension V_5. The beveled surface of slide *D* has meanwhile slipped on that of slide *C* so that corners *f* and *h*, which were in contact, have reached positions *f'* and *h'*, a distance measured by dimension V_4. It is evident then that V_3, V_4, and V_5 may be taken as measures of relative velocities of the parts in question.

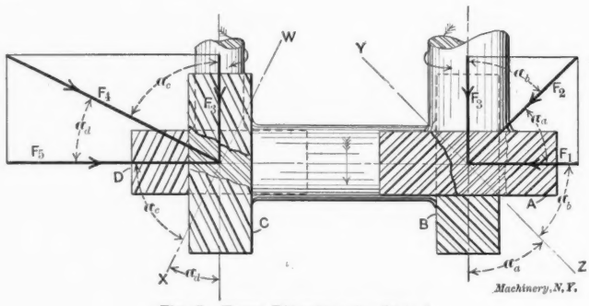


Fig. 2. Force Diagrams for Case 1.

Since the mechanism shown in Fig. 4 represents, in principle, conditions existing between gear *C* and *D* in Fig. 5, we may transfer the velocity diagram of Fig. 4 to Fig. 5, where V_5 represents the pitch velocity of gear *D*, V_4 the rate of rubbing at the pitch line between gears *C* and *D*, and V_3 the circumferential velocity at the pitch line of gear *C*. The circumferential velocity at the pitch line of gear *B* is evidently the same as that of gear *C*, since they are of the same diameter and move together. V_3 being thus known, a similar velocity diagram may be drawn for gears *A* and *B*, in which V_1 equals the velocity at the pitch line of gear *A*, and V_2 equals the velocity of sliding between the teeth of gears *A* and *B*.

We may, if we wish, measure these lines to the scale $V_1 = 1$ to obtain the relative velocities desired, or, better, we may derive formulas from these velocities, thus making unneces-

* For additional data on the calculation, design and cutting of spiral gears see the following articles previously published in MACHINERY: Spiral Gears, September, 1903 (Engineering Edition only); Figuring a Pair of Spiral Gears, January, 1904; Cutting Spiral Gears, October, 1905; Method of Procedure in Design of Helical Gears, May, 1906.

sary the drawing of diagrams for subsequent examples of this kind. By a simple use of trigonometrical functions, after carefully examining the diagrams, it is plain that the following relations hold true:

$V_1 = 1$
$V_2 = V_1 \div \sin\ a_a = 1 \div 0.707 = 1.414$
$V_3 = V_1 \times \tan\ a_b = 1 \times 1.000 = 1.000$
$V_4 = V_3 \div \sin\ a_c = 1 \div 0.894 = 1.118$
$V_5 = V_3 \times \tan\ a_d = 1 \times 0.500 = 0.500.$

The power lost in any bearing is equal to the continued product of the total pressure on that bearing, the velocity of sliding, and the coefficient of friction. We will first find the power lost in end thrust. Since our calculation is being made for comparison only and not for positive results, we will consider the coefficient of friction as being equal to 1. We will make the assumption that the mean diameter of the end thrust bearings of the various shafts is equal to half the pitch diameter of the gears. The mean velocity of rubbing will then be half the velocity of the gears at the pitch line. For the loss of power in the thrust bearing of shaft A we have:

$$F_3 \times \frac{V_1}{2} \times 1 = 0.500 \times 0.500 \times 1 = 0.250.$$

The end thrust on the intermediate shaft is that due to the difference between the opposing forces F_1 and F_5 in Fig. 2. For lost work in the end thrust of the intermediate shaft we then have:

$$(F_5 - F_1) \times \frac{V_3}{2} \times 1 = (1 - 0.500) \times 0.500 \times 1 = 0.250.$$

The loss in the thrust bearing of shaft D equals

$$F_3 \times \frac{V_5}{2} \times 1 = 0.500 \times 0.250 \times 1 = 0.125.$$

Adding these three losses together we get a total value of 0.625 as the power loss in end thrust.

For the power loss in tooth friction, we had better use a somewhat higher coefficient; perhaps 1.5 would be about right. The velocity of sliding between gears A and B is V_2, the normal pressure of the surfaces of contact is F_2. We have then for the lost power at this point:

$$F_2 \times V_2 \times 1.5 = 0.707 \times 1.414 = 1.500.$$

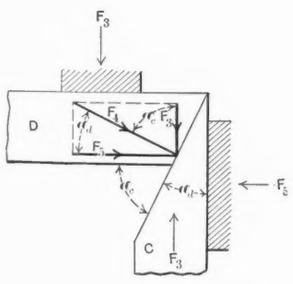


Fig. 3. Illustration of Principle Involved in Fig. 2.

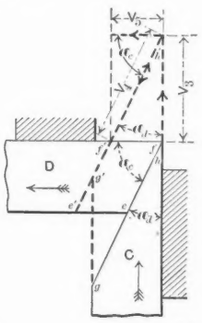


Fig. 4. Illustration of Principle Involved in Fig. 5.

Similarly the work lost between gears C and D equals

$$F_4 \times V_4 \times 1.5 = 1.118 \times 1.118 \times 1.5 = 1.875.$$

The total loss due to tooth friction is then equal to the sum of these two or 3.375, which, added to the loss in the thrust bearings, gives us 3.375 + 0.625 = 4.0, the total loss with this form of bearing.

It will not be necessary to draw new diagrams, like those in Figs. 2 and 5, for the second case, since we may use the formulas already derived for obtaining the various forces and velocities, making, however, the following substitutions. This change is in accordance with the data in Case 2.

Change a_a to $a_e = 63° 26'$
" a_b to $a_f = 26° 34'$
" a_c to $a_g = 45°$
" a_d to $a_h = 45°$.

Solving these formulas for velocities, we obtain the following quantities:

$V_1 = 1$
$V_2 = V_1 \div \sin\ a_e = 1 \div 0.894 = 1.118$
$V_3 = V_1 \times \tan\ a_f = 1 \times 0.500 = 0.500$
$V_4 = V_3 \div \sin\ a_g = 0.500 \div 0.707 = 0.707$
$V_5 = V_3 \times \tan\ a_h = 0.500 \times 1.000 = 0.500$

and for pressures we have the following:

$F_5 = 1$
$F_4 = F_5 \div \sin\ a_g = 1 \div 0.707 = 1.414$
$F_3 = F_5 \times \tan\ a_h = 1 \times 1.000 = 1.000$
$F_2 = F_3 \div \sin\ a_e = 1.000 \div 0.894 = 1.118$
$F_1 = F_3 \times \tan\ a_f = 1 \times 0.500 = 0.500.$

The work lost with the thrust bearing on shaft E equals

$$F_3 \times \frac{V_1}{2} \times 1 = 1 \times 0.5 \times 1 = 0.5.$$

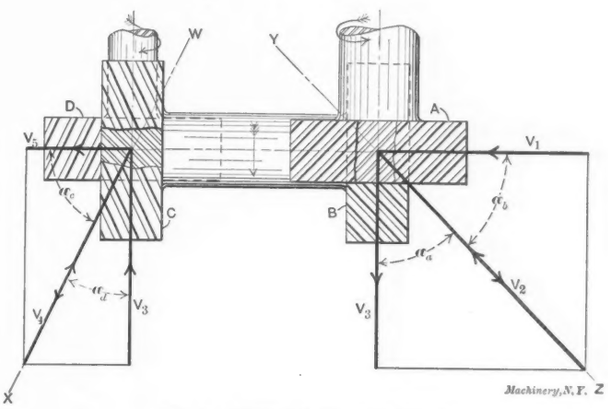


Fig. 5. Velocity Diagrams for Case 1.

That lost in the intermediate shaft equals

$$(F_5 - F_1) \times \frac{V_3}{2} \times 1 = (1 - 0.5) \times 0.25 \times 1 = 0.125.$$

The loss in power due to end thrust in shaft H equals

$$F_3 \times \frac{V_5}{2} \times 1 = 1 \times 0.25 \times 1 = 0.25.$$

These three losses added together equal 0.875.

The loss of power due to tooth friction between E and F, assuming a coefficient of friction of 1.5 as before, equals

$$F_2 \times V_2 \times 1.5 = 1.118 \times 1.118 \times 1.5 = 1.875.$$

Friction loss between G and H equals

$$F_4 \times V_4 \times 1.5 = 1.414 \times 0.707 \times 1.5 = 1.5.$$

The tooth friction loss in the tooth surfaces then equals 1.875 + 1.500 = 3.375. For Case 2 the total lost work due to tooth friction and end thrust friction equals 3.375 + 0.875 = 4.250. The difference between this quantity and the 4.000 obtained for Case 1 is scarcely large enough to "shake a stick at," as the phrase is. There is but one consideration, in fact, we can think of for preferring one construction to the other. The 45-degree gears have teeth of slightly smaller size than those of the other pair in each case, and they are therefore somewhat weaker. In Case 1, these teeth are subjected to a normal pressure F_2 of 0.707. In Case 2 they are subjected to a normal pressure F_4 of 1.414, twice as great. In Case 1, then, the strongest teeth are bearing the greatest strain, which is as it should be.

* * *

A gas plant of imposing dimensions is in course of construction at Astoria, Long Island. The *Engineering News* says that when the entire plant is finished it will spread over 400 acres of land. In this area, however, is included that necessary for the building of a large number of model homes for the employes. The six holding tanks will each have a capacity of 15,000,000 cubic feet. These tanks will have a diameter of 300 feet; they will reach down into the earth for 50 feet, and will tower above ground 150 feet. Up to this time the largest gasholding tank has been one in London with a capacity of 12,500,000 cubic feet.

REMARKS ON THE MAKING OF HAND TAPS.—1.*

ERIK OBERG.†

The following remarks, and the information and data given, are intended to supplement a number of articles on tap making which have appeared in MACHINERY during the last three years. The subject is of too great a scope to be treated in a single article or a single issue. But if the various articles that have appeared are studied collectively, these articles will be found to contain a fairly complete treatment of the subject in hand, the most complete, in fact, the writer would venture to say, that has as yet appeared in the engineering press, whether the periodical literature or that in book form is considered. While there has been a great deal written on the subject, there has not been as yet a complete compilation of the data belonging to it. For this reason it seems appropriate to add some additional information, and to bring out some points for discussion, so that the available data and the somewhat differing opinions in regard to tap making may all be recorded in such a manner that reference to them may be easy, and information readily obtained.

Requirements for Correctly Threaded Taps.

There are, in correctly threading a tap, six distinct points to take into consideration. The tap must be provided with the correct diameter in the angle of the thread, a correct outside diameter, correct lead, correct angle between the sides of the thread, correct relation of this angle to the axis of the tap, and finally correct flats or radii at the top and bottom of the threads, as required by the standard thread form. The angle diameter, for instance, may be correct while the outside diameter would be a trifle large or small, depending upon whether the flat or radius at the top of the thread were either too small or too large. The lead, of course, may be incorrect, while the other factors are practically correct. The angle of the thread may be larger or smaller than the standard angle, and if the lead, the outside diameter and the angle diameter were still approximately correct, the tap would produce a very poorly fitting thread. The angle between the sides of the thread may be correct in itself, but the thread-cutting tool may have been presented to the work at an oblique angle, thus producing a thread that would not be symmetrical about a line through the center of the thread at right angles to the axis of the tap. It is evident that all these requirements in regard to threading must be filled in order to make a perfect tap.

In manufacturing, where tools and holders specially made for the purpose are used in threading taps, there is little danger of the inaccurate or unsymmetrical angles of the thread. It is therefore the practice simply to inspect the angle diameter and the lead of the tap. If these two prove correct within the prescribed limits, and if the outside diameter of the tap blank was inspected before threading, there is little danger of any serious inaccuracies in respect to the other details of the thread. It must, however, be understood that the threading tools and the alignment of the threading lathes must be subject to inspection at certain intervals, if the chances of error are to be as much as possible guarded against.

Fluting Hand Taps.

The flutes of a tap serve two purposes. They provide for cutting edges for the threads and form channels for the carrying off of the chips. The form of the flute is greatly important, as it determines the cutting qualities of the tap as well as the ease with which the chips will be able to pass away from the cutting points. The main qualities looked for in a tap are strength and ease of working, provided the tap is otherwise correct. In order to obtain strength, a shallow flute with no sharp corners is the first requirement. An easy-working tap again requires a considerable amount of chip room and consequently a comparatively deep flute. The correct flute, therefore, is a compromise between a flute which will give the greatest amount of chip room and the greatest strength to the tap. Besides this, the fluting cutter must be of such shape as to be easily produced and easily kept in good order, and with a form of teeth as will permit heavy chips to be taken when the taps are fluted.

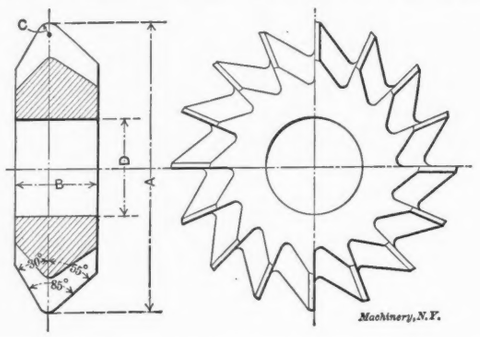
Fluting Cutters for Hand Taps.

The present practice is to provide hand taps with deep straight-sided flutes having a small round at the bottom produced by a cutter such as is shown in connection with Table I. The included angle between the sides is 85 degrees, 55 degrees on one side and 30 degrees on the other. The thickness of the cutter should be approximately equal to 7-16 D + 5-16 inch, if D equals the diameter of the tap. The radius of the cutter ought to be equal to $\frac{D}{4}$, but should not in any case exceed 7-16 inch. The diameter of the cutter depends, of course, not only upon the diameter of the tap to be threaded, but also on the size of the hole in the cutter for the milling machine arbor. The common practice is to use cutters with ¾-inch hole for the smaller diameters of taps, say up to and including ¾-inch, and 1-inch hole in cutters for large diameter taps. In such a case one can make

$$\text{Diameter of cutter} = \frac{D}{2} + 2 \text{ inches},$$

in which formula D, as before, equals the diameter of the tap to be threaded.

TABLE I. DIMENSIONS OF FLUTING CUTTERS FOR HAND TAPS.



Diameter of Tap.	Diameter of Cutter.	Thickness of Cutter.	Radius.	Diameter of Hole in Cutter.
	A	B	C	D
¼	2	⅜	1/16	¾
⅜	2¼	½	3/32	¾
½	2¼	½	⅛	¾
⅝	2¼	⅝	5/32	¾
¾	2¼	⅝	3/16	¾
⅞	2½	¾	7/32	1
1	2½	¾	¼	1
1¼	2½	⅞	5/16	1
1½	2¾	1	⅜	1
1¾	2¾	1⅛	7/16	1
2	3	1⅛	7/16	1
2¼	3	1¼	7/16	1
2½	3¼	1⅜	7/16	1
2¾	3¼	1½	7/16	1
3	3½	1⅝	7/16	1
3½	3¾	1⅞	7/16	1
4	4	2	7/16	1

Table I. is figured from the formulas given. The figures given in the table are, however, practical working figures and are only approximately the values figured from the formulas, whenever these values give dimensions unnecessarily fine and in too small fractions. Of course, the nearest ¼ of an inch is near enough for the dimension in regard to diameter, and the nearest ⅛ inch in regard to thickness. The radius, however, must be given in finer sub-divisions, as 1-32 or even 1-64 inch makes a considerable difference in this respect. The lands of the tap, when threaded with cutters having rounded instead of straight sides, may be somewhat narrower than the lands in taps threaded with the cutters just described, because

* For additional information regarding the making of hand taps see the following articles previously published in MACHINERY: Tool making: Taps, April, 1904; Proportions of Hand Taps in Sets, December, 1905; Acme Taps in Sets, January, 1905; Square Thread Taps in Sets, March, 1905; Relief of Taps, October, 1905; Lathe Gearing Compensation for Changes of Lead due to Hardening, April, 1905; Formulas for Determining the Proportions of Taps, January, 1907 (Engineering Edition only); Table of Dimensions, Data Sheet Supplement, January, 1907.

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the latter tap requires wide lands in order to make up for the loss of strength due to the straight-sided, deep, sharp-cornered flute. It must be remarked, however, in this connection, that the width of the lands does not depend entirely upon the necessary strength of the tap. As a hand tap, as a rule, receives all its guidance from its lands resting against the walls of the nut to be threaded, it is necessary to have the lands wide enough so that they steady the tap during the tapping operation.

Number of Flutes.

The correct number of flutes can be found approximately from the formula

$$\text{Number of flutes} = \frac{11\,D}{8} + 2\tfrac{3}{4},$$

in which formula D equals the diameter of the tap. If one figures a table from this formula, one will find the number of flutes for various diameters as stated in Table II. It will be noticed that the number of flutes for hand taps in this table are given as 4, 6 and 8, the odd numbers 3, 5 and 7, which would ordinarily also be the results obtained from the formula, not being used. The reason for this is that an even number of flutes enables one to measure the diameter of the tap in all cases with ordinary micrometers. If an odd number is used, the measuring of the diameter is rather complicated, and requires a gage to which to fit the tap. Even then there will still be more or less uncertainty unless the tap is of standard diameter.

TABLE II. NUMBER OF FLUTES IN HAND TAPS.

Diameter of Tap.	Number of Flutes.	Diameter of Tap.	Number of Flutes.	Diameter of Tap.	Number of Flutes.
¼	4	1	4	2½	6
⅜	4	1¼	4	2¾	6
½	4	1½	4	3	6
⅝	4	1¾	6	3½	8
¾	4	2	6	4	8
⅞	4	2¼	6	..	..

In regard to the number of flutes there is some difference of opinion. There are those who consider four flutes the proper number to use on all sizes of taps with the width of the land about one-fourth the diameter of the tap. However, on large taps the land will be rather wide if made according to this rule, and better results will be obtained by increasing the number of flutes in accordance with the formula previously given.

Convex Fluting Cutters.

Sometimes ordinary convex cutters are used for fluting taps. A formula,

$$T = \frac{8\,D}{3\,A},$$

for the thickness of a half-round cutter to be used for fluting taps, was given in MACHINERY, June, 1906. In this formula

T = thickness of the cutter,
D = diameter of the tap,
A = number of the flutes.

If we, for instance, wish to flute a 1-inch tap with four flutes, the thickness of a convex cutter for the purpose would be

$$\frac{8 \times 1}{3 \times 4} = \frac{8}{12} = 0.667, \text{ or 11-16 inch, approximately.}$$

Cutting Taps with Dies.

While it is rather common to cut the threads on taps with dies, instead of cutting the thread in a lathe, it is a practice which can hardly be recommended. Any inaccuracy in the lead of the thread of the die will be duplicated in the tap, and still further augmented by the change in lead in the tap due to hardening. Sometimes, when the threads on small taps are cut with dies in screw machines, it is found that the taps have a "stretched" thread, or in other words, that the lead of the thread is longer than the standard lead. On examination the die may be found to be properly made, but further investigation may show that the heavy turret slide of the screw machine was dragged along with the die, and this has caused the thread to stretch, making the lead long. For this reason it is not advisable to cut the thread of taps, which are required to have the highest possible degree of accuracy, in a screw machine. It is particularly bad practice in the case of taps with a long threaded portion or taps used for threading long holes, as the inaccuracies in lead will be so much the more pronounced.

The opinion that taps stretch or become long in the lead when cut by dies in screw machines, is one that is not universally accepted, and it must be admitted that the reason given for this occurrence does not seem entirely plausible. Whatever be the cause, however, the fact that taps cut in screw machines are liable to be inaccurate remains undisputed.

It is true that it is the practice with some firms manufacturing taps to cut the thread with dies in a screw machine, but in the case of manufacturing some factors enter which make this permissible. In the first place, the difference in price when threading in a screw machine or cutting the thread in a lathe is so great that a number of taps can be thrown out at the final inspection, if their inaccuracy in lead is greater than the limits of error permitted, and a saving may still be the result of the method employed. It must be understood, however, that such a procedure is applicable only to small taps, where the loss of material is not very significant, should a tap not pass the inspector, but this process should not be applied to taps where it is wanted to insure great accuracy. In such cases nothing can compare with a thread cut in a lathe, provided with a lead screw which itself has been properly tested as to its own accuracy. For ordinary machine screw taps, however, in manufacturing, the screw machine may answer the purpose and prove economical.

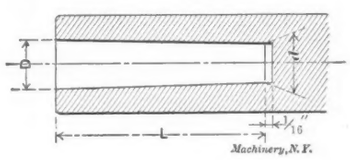
* * *

TABLE OF JARNO TAPERS.

In the How and Why section of our April issue we had occasion to refer to the Jarno standard taper, and we gave there the standard formulas for this taper. Mr. Arthur B. Babbitt, of Hartford, Conn., has sent us a table of Jarno tapers giving the large and small end and the length of the taper. These dimensions, as we previously remarked, are easily found from the formulas, but some of our readers may appreciate having a table figured out.

Taper per foot = 0.600 inch.
Taper per inch = 0.050 inch.
No. of taper = N.

$$D = \frac{N}{8} \qquad d = \frac{N}{10} \qquad L = \frac{N}{2}$$



No. of Taper.	D	d	L
2	.250	.20	1
3	.375	.30	1½
4	.500	.40	2
5	.625	.50	2½
6	.750	.60	3
7	.875	.70	3½
8	1.000	.80	4
9	1.125	.90	4½
10	1.250	1.00	5
11	1.375	1.10	5½
12	1.500	1.20	6
13	1.625	1.30	6½
14	1.750	1.40	7
15	1.875	1.50	7½
16	2.000	1.60	8
17	2.125	1.70	8½
18	2.250	1.80	9
19	2.375	1.90	9½
20	2.500	2.00	10

* * *

When doing some job work on electric wiring, do not run flexible wires over boxes, partitions or into closets. Have permanent wiring installed. Flexible wires used in this way may prove dangerous.

PUMPING SAND.

JOHN BRADFORD.*

The hydraulic dredge during the past decade has been used quite extensively, and the usefulness of the pump in connection with dredging fully demonstrated and firmly established. The dredging of sand, gravel, mud, or marl can be done with a centrifugal pump at much less cost than is possible with the old style dipper, or scoop dredge. There are various reasons why the pump is more economical: First, the initial cost of the plant is very much less, and likewise the cost of maintenance, as there are less repairs to be made and not so many men needed in its operation. In addition to this, where there is sand, gravel, or other material that will readily pass through a pump, it can be raised more rapidly than is possible with the dipper, or scoop dredge.

The centrifugal pump is universally used for dredging, and is by far the best type for this purpose, although we shall consider later a sand pumping problem where it would prove inadequate. A dredge pump differs somewhat from the standard type. The pistons or fans are generally fitted with water bearings to prevent the sand from cutting the journals, and are so designed that sand or gravel passing through them does not materially increase the clearance between the fan and pump casing, which would, of course, impair the pump's efficiency. Most dredge pumps have two suction pipes, thus extending the range of operation. The ends of these pipes are fitted with what is known as a "sand agitator," a device for loosening the material so it can be easily drawn into the pump. Some pipes simply have spiked ends which drag along through the sand, while at least one large dredge is equipped with steel spiked wheels which are actuated by a special engine. Then there is the "water jet" type, acting under a pressure of from 60 to 100 pounds furnished by a special duplex pump. The dredge "Iota," one recently built for work on the Mississippi river, is fitted with this latter type. This particular dredge has been doing excellent work, and has exceeded the expectation of its designers. The pump is of large centrifugal type, having a 32-inch discharge, and is capable of delivering at least 1,000 cubic yards of sand per hour through 1,000 feet of pipe. The discharge pipe is made of one-quarter inch steel plate, and the fifty sections coupled with swivel joints, are supported upon pontoons. Of course, there is much greater economy where the material can be raised and discharged through pipes to the shore in one operation, which generally can be done in river and harbor work.

The proportion of sand to water that can be pumped, depends on its fineness and specific gravity. In a well-equipped plant working under favorable conditions, the proportion of sand is about fifty per cent. The calcareous, and argillaceous sands flow more freely than the siliceous, and there is less liability of them clogging the discharge pipe. The pumps usefulness in connection with this work is not confined alone to dredging. Where large quantities of sand are to be transported from one point to another, the pump has in some instances taken the place of the horse with most economical results. The writer having inspected one such plant, will give a few details concerning its operation.

The sand, which is siliceous and used for making glass, is taken from the mine in a lumpy condition, which necessitates first the use of a crusher for its disintegration. It is then fed into a revolving sieve, and after the sifting process, it is carried by a conveyor through a series of troughs filled with running water. After being washed and made marketable, it is ready to be pumped to the point of shipment almost a mile distant. The centrifugal pump so well adapted to this class of work could not well be used here, owing to the great length of the discharge line. The work is accomplished, however, with fairly good results by a 14 x 6 x 12 inch direct-acting outside packed plunger pump. The discharge pipe is four inches in diameter, and its maximum height above the pump is forty feet. There are few curves in it, and none of them under 125 feet radius. The sand and water must be forced through this with considerable velocity, to prevent the sand from precipitating in, and clogging the line. Of course the wear on the pump is excessive. The plungers, which are cast steel, last about six months, and are packed with flax-packing which has given the best results. The valves are the "flap" type, and of rubber, the quality determining the length of time they can be used, the best being unfit for use after one month's service. It is obvious that this pump should be kept in good repair, as a sudden stop would mean clogging the entire discharge line with sand.

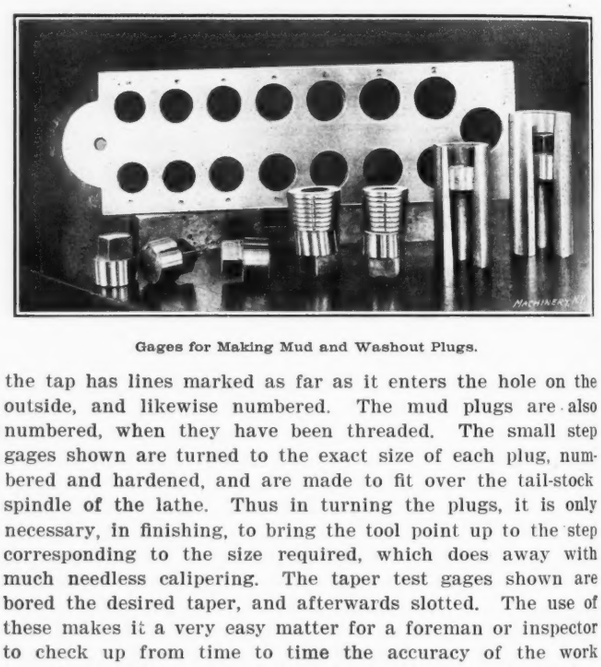
When it is desired to stop the pump, the sand is shut off, and clear water pumped until the discharge line is entirely clear. One hundred and fifty tons of this sand are pumped during the ten hours run, from the mine to the "dry house," where, after the drying process, it is ready for shipment.

* * *

GAGES FOR MAKING MUD AND WASH-OUT PLUGS.

M. H. W.

In traveling around among various shops I find in many instances no particular care being taken to insure well-made and uniform mud and washout plugs. Of course, many shops have excellent methods to produce first class plugs, and I am not addressing these remarks to such shops but only to those who have as yet not made special devices for this class of work, and who by force of circumstances are making these plugs in a common lathe, possibly depending upon a first year apprentice to do this most important job. The accompanying cut shows a plate tapped out to suit the various sizes of plugs likely to be required. The holes in the plate are numbered,



Gages for Making Mud and Washout Plugs.

the tap has lines marked as far as it enters the hole on the outside, and likewise numbered. The mud plugs are also numbered, when they have been threaded. The small step gages shown are turned to the exact size of each plug, numbered and hardened, and are made to fit over the tail-stock spindle of the lathe. Thus in turning the plugs, it is only necessary, in finishing, to bring the tool point up to the step corresponding to the size required, which does away with much needless calipering. The taper test gages shown are bored the desired taper, and afterwards slotted. The use of these makes it a very easy matter for a foreman or inspector to check up from time to time the accuracy of the work turned out. These gages, it is understood, are not threaded.

* * *

A correspondent in the course of a recent contribution referred to the assertion of an engineer that the crank-pin of a large Corliss engine ran so well with a certain kind of bearing that it was actually *cooler* than the surrounding atmosphere. This was attributed by the engineer to the cooling effect due to its rapid motion through the warm air of the engine room. This queer idea, of course, is not supported by the fact. A warm breeze blowing on one's body does give the sensation of coolness but it is so simply because of the increased evaporation from the skin. In the case of a dry piece of metal such effect is entirely absent, and it can by no possibility have a lower temperature than the surrounding air. The only reason that an electric fan is of any value on a hot day is simply that of circulating the air and increasing the evaporation of the body, thereby reducing its temperature. An electric fan in a refrigerator would be as good as nothing at all; in fact it would tend to raise the temperature as the friction of the flowing air would create heat.

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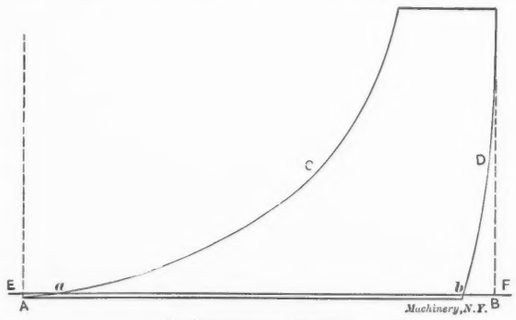
STANDARDS OF EFFICIENCY IN COMPRESSED AIR PRACTICE--THE AIR COMPRESSOR AS AN AIR METER.

FRANK RICHARDS.*

Nothing, perhaps, is more common in engineering practice than to state results as percentages of efficiency. Nothing is also perhaps more common than a certain vagueness and uncertainty of standard, with processes of deduction which are often incorrect or unreliable. We accept stated percentages of efficiency without sufficient scrutiny, and as a consequence some things in mechanical or engineering lines obtain credit and apparent practical endorsement which are not their due.

A few years ago there was being exploited a certain device —not pneumatic—for raising water, the principle employed being ultimately that of the hydraulic ram, operating not directly, but through a series of mechanism. Given a body of water at a certain level *A* from which it is to be raised to another level *B* the vertical lift would of course be the height *A B*, and if a steam pump had been employed it would have



Air Compressor Diagram.

been credited with that lift. In this case, however, the conditions of operation required that a certain weight of water should fall from the level *A* to a lower level *C*, the foot-pounds of this fall being taken as the power expended, which was all right. The water raised, however, was credited with being raised from this lower level *C*, or through the height *C B* instead of the height *A B*, which gave the device probably one-third greater efficiency than it earned, and although it has not come into permanent use, its handsome record thus computed is to be found embalmed in some mechanical textbooks and works of reference.

We have before us an interesting example in the computation and assignment of efficiencies in the case of a certain device for raising or pumping water by the use of compressed air, where the percentage of efficiency of the apparatus is put forth in the usual way, and all are expected to accept it as absolutely correct and unquestionable. There is no suggestion here that the computer of the percentage was not perfectly honest or that there was any intention to bias the results in either direction, but still the results, or rather the assumptions upon which they are based, invite some criticism.

The unit assumed was the power used to compress the air as shown by the indicator card of the air compressing cylinder; then the foot-pounds of the water lifted made the percentage of this. Now, this cannot possibly be correct practice, because the efficiency of the compressor is here mixed with that of the pump, and the efficiency of the latter could be made to vary widely according to the style of the compressor employed. If one wanted in this case to show as high a percentage as possible for his air-operated device he would employ the best compressor and the best conditions of compression possible. If the air pressure employed was high enough to make two-stage compression the more economical, then the power shown by the sum of the indicator cards of the two air cylinders would be less than the power shown for the same work by the card from the single cylinder of the single-stage compression, and the former would give the pump a higher efficiency than the latter, although its actual work was identical in the two cases.

Comparative efficiencies in two or more cases of pumping under different conditions might, of course, be computed from the power record of the air cylinder of any compressor, provided the entire output of compressed air was used by the pump in each of these cases, but nothing could be accurately deduced from it as to the *absolute* efficiency in either case.

Indicator Card Best Basis for Computing Efficiency.

The indicator card of the air compressing cylinder does, after all, provide the best basis from which to compute the efficiency of air operated devices, but not by its power record. There seems to be nothing by which compressed air efficiencies can be reliably measured but the actual consumption of air, and the air compressor is the best air meter known. To use the air compressor as an air meter its computed piston displacement per stroke, allowance being made for piston rod and also for piston inlet pipe if used, requires to be corrected by the evidence of the indicator card, and nothing else will do it.

The air cylinder at the beginning of the compression stroke is not normally full of air in advance of the piston at full atmospheric pressure, but somewhat lower. Usually the piston must advance an appreciable and easily measurable distance, and must have begun its actual work of compression before the compression line *C* rises to and coincides in vertical position with the atmosphere line as at *a*, and only when these lines do coincide can we say that the cylinder in front of the piston is filled with air at precisely atmospheric pressure, or free air. Then at the other end of the stroke all of the air compressed is not expelled from the cylinder on account of clearance spaces which the piston at the end of its compression stroke cannot entirely occupy, and thereby displace and expel all the air, so that upon the return stroke of the piston this air first of all re-expands down to atmospheric pressure, the atmosphere line *E F* not being reached by the re-expansion line *D* until the piston has traveled a portion of its return stroke. The free air, or the air at atmospheric pressure, actually compressed and delivered is the contents of that portion of the cylinder represented by the distance between the point *a* where at one end the compression line rises to and crosses the atmosphere line and the point *b* near the other end of the stroke where the re-expansion line drops to and touches the atmosphere line again, this distance being compared with the total length *A B* of the indicator card in computing the capacity percentage, the latter of course representing the total piston displacement per stroke. What the percentage may be, or the difference between the theoretical and the actual delivery, can only be precisely determined, in this case, by the evidence of the indicator card, and each compression cylinder has its own individual equation. The figure here used for illustration shows the atmosphere line and the intake line as entirely separated, which is not often found in practice.

Influence of Temperature.

When we have thus ascertained the actual volume of air delivered per stroke at atmospheric pressure, and its percentage of the entire capacity of the compressing cylinder, there still remains a question as to the temperature of the air, this also affecting the ultimate result. If the temperature of the air filling the cylinder is higher than normal, then its volume also will be proportionately greater, and the air when cooled to the normal temperature will be reduced in actual volume, and by this the percentage of compressor capacity will also be still further reduced.

As to the actual temperature of the air filling the cylinder at the beginning of any compression stroke it would seem that there must always be more or less uncertainty, as there is no means known for ascertaining and proving the temperature within the cylinder at any precise moment. One thing, not generally recognized, is that with the compressor running at full speed the temperature of the air in the cylinder at the end of the re-expansion and the beginning of the intake is not high, that in fact the temperature is presumably somewhat lower than that of the incoming air.

It is well understood that the temperature of air always rises during compression and *simultaneously with the compression*, so that the temperature at any instant during any act of compression is always that due to the compression in

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addition to the initial temperature. If any heat is given off from the air during or upon the completion of the compression, as for instance to the body of the cylinder, to the cylinder head or to the body of the piston, then the temperature of the compressed air will be somewhat lower than precisely that due to the compression. We know that the air during its compression and after compression, but before its expulsion from the compressing cylinder, does give off some of its heat, because the cylinder and the piston are heated by this action, thus giving occasion for the employment of the water jacket or other cooling devices.

As the temperature of the air rises during compression, so it correspondingly falls during expansion, simultaneously with the expansion and in inverse ratio, precisely corresponding to its rise during compression. If a body of air at any initial temperature is compressed by the contraction of the space in which it is confined from any initial pressure to any higher pressure, then upon the restoration of the space to its original dimensions and the fall of the pressure of the air to the initial pressure, the temperature of the air becomes precisely what it was at the beginning of the compression; and if the temperature of the air at the beginning of this re-expansion is at all lower than that actually due to the compression, then the temperature upon the termination of this re-expansion back to initial pressure must also be lower than at the beginning of the compression. It is quite demonstrable, therefore, that in the actual, practical operation of an air compressor the air at the end of the compression stroke is not quite as hot as it would be if its giving off of heat were entirely prevented, and its re-expansion down to initial pressure therefore leaves its temperature somewhat lower than that at which it entered the cylinder before its compression had begun.

Up to the precise moment when re-expansion in the cylinder begins the air is being cooled somewhat by giving off some of its heat to the cylinder and piston, then after re-expansion begins we must admit that this process is reversed, but the time elapsing before the re-expansion is completed is so short that this re-heating has little effect, and it seems quite certain that the air in the cylinder—this re-expanded air filling the cylinder space at the beginning of the intake stroke—is cool air, certainly cooler than at the beginning of its compression.

As to the temperature of the new charge of free air which enters the cylinder for the succeeding compression stroke we must acknowledge that its temperature is never lowered in any compressor known and is generally raised by its contact with the more or less heated metal surfaces as it enters to fill the cylinder. The different ways in which the air enters the cylinder, or the style, number and arrangement of the inlet valves, and the directness or the sinuosity of the admission passages make different rates of opportunity for the air to absorb heat as it passes in. It may be said in a general way that the more the air is subdivided and the more numerous, intricate and minute the passages by which it enters the cylinder, the more chance it has to be heated.

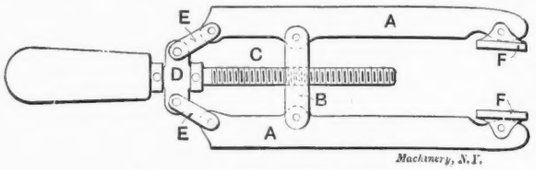
Effect of Inlet Valves.

The inlet valve arrangements of different compressors are almost as numerous as their builders, and there would be little profit in discussing them. There is, however, one inlet valve arrangement which seems to have the right to claim special mention in that it is unique and absolutely alone among all the devices employed, and this is the piston inlet valve. By the use of this valve the intake air passes through the piston inlet pipe, which is not hot, in a solid column and at a speed approximating and often exceeding a mile a minute. Its mass remains equally unbroken in the body of the piston, and then its passage of the lips of the single valve and valve seat is, for any portion of it, instantaneous. The rise of temperature which occurs to the air in its passage into the cylinder by this route would seem to be quite minute, and this rise of temperature seems to be the only thing to be allowed for in accepting the air compressor, upon the evidence of its indicator card, as a reliable air meter. It therefore would seem to be absolutely reliable for record of air compressed and actually delivered, to within, say, five per cent, which is as near as the average gas or water meter works.

ITEMS OF MECHANICAL INTEREST.

IMPROVED PATTERN-MAKER'S CLAMP.

An interesting clamp for pattern-makers and others is shown in the *Zeitschrift für Werkzeugmaschinen und Werkzeuge*. As seen from the cut, the device consists of two levers *A*, turning around pivots in the intermediate part or brace *B*, which latter is threaded to receive the clamp screw *C*. On this

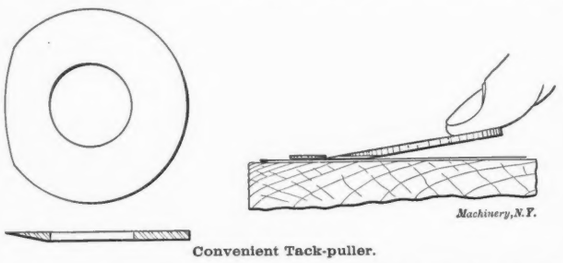


Improved Pattern-maker's Clamp.

clamp screw is mounted a bushing *D*, provided with projections to which are connected the links *E*. These links in turn are connected with the levers *A*. The lower part of the levers carry swiveling jaws *F*. The action of the clamp is readily perceived from the cut; the clamping pressure is evidently very great on thin work, due to the toggle action of links *E E*. In the position shown, however, it is not so effective.

A CONVENIENT TACK-PULLER.

The cut shows a simple and effective tool noticed in a drafting room recently, used for drawing thumb or other tacks. It is made by holding a half-inch washer to the face of a revolving grindstone or emery wheel until the operator is satisfied with the shape produced. The edge is sharpened so it can be pushed under the head of the tack, when the thumb

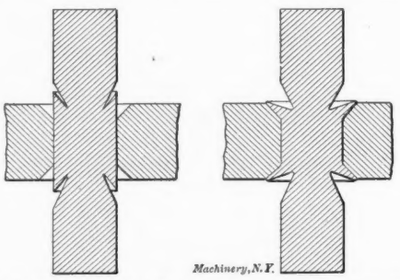


Convenient Tack-puller.

of the operator, pressing on the upper edge as shown, withdraws the tack. This little instrument is well enough known, but perhaps there may be some draftsmen who have never happened to see it. Its special advantages are the ease with which the stock it is made from can be obtained and the convenient hole with which it is provided, which allows it to be attached to a string and suspended from the drawing table.

METHOD OF FASTENING SMALL PULLEYS OR DISKS TO STUDS.

The Siemens-Schuckert Works in Berlin, Germany, has patented a method of connecting small disks to the studs carrying them. The method is specially intended for electrical connections and adapts itself well for copper studs. The cut



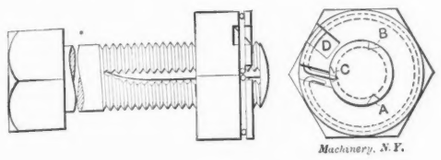
Method of Fastening Small Pulleys or Disks to Studs.

herewith, which is taken from *Zeitschrift für Werkzeugmaschinen und Werkzeuge*, plainly shows the method of fastening. The stud is inserted in the disk, the hole of which latter is chamfered on both sides. An angular cut is taken in the stud on each side of the disk with a pointed tool, as shown, and the lip portion formed by the cut is bent outward into the chamfered portion of the hole of the disk, thus keying

the disk to the stud as well as preventing end play. For purposes where an electric connection is wanted rather than a joint taking a heavy thrust, this method has proven very satisfactory.

POSITIVE LOCK NUT.

The accompanying illustration (taken from the *Horseless Age*, February 20, 1907) shows a lock nut and bolt invented by a Chicago man. The bolt has three grooves, *A*, *B* and *C*, which act as ratchet teeth. The upper part of the nut is so formed that a spring ring encircles it, the end of the ring being turned inward, as shown at *C*, thus coming in contact

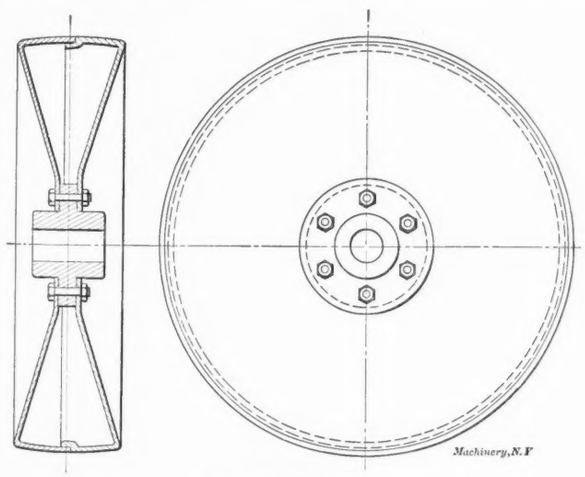


Positive Lock Nut.

with the side of the groove and effectually preventing the nut from being turned in a left-hand direction. However, right-handed rotation is possible, as the grooves are so shaped that the end of the spring ring slides up the inclined surface easily. In order to release the nut, a slot, *D*, is provided, which allows the point of a nail or any similar object to be placed under the spring ring and thus raise the point out of the groove, when the nut can be taken off. This arrangement allows an adjustment at any time of one-third of a rotation.

STAMPED STEEL PULLEYS.

A new form of pulley, introduced by Messrs. Walker & Holroyd, Laisterdyke, Bradford, England, is described and illustrated in the *Mechanical World*, April 5, 1907. A line cut showing the design of these pulleys is given below. The pulleys are made up of two drawn steel stampings, each of which is concave in form. One half has a portion bent down along its periphery, and the other half fits into the groove produced. The hub is of cast iron and is secured to the pul-

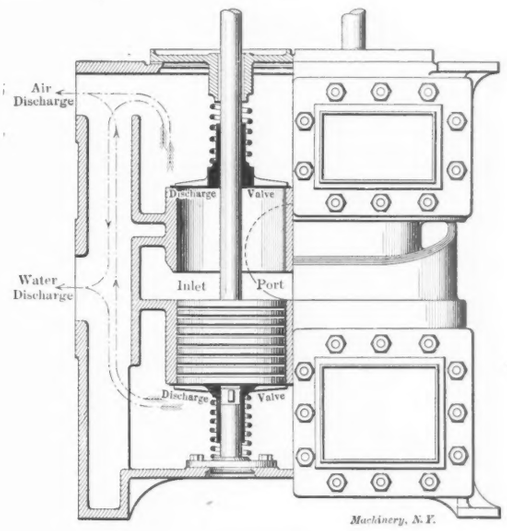


Stamped Steel Pulley.

ley body by rivets or screws. These pulleys, according to the claims of the makers, are 30 to 40 per cent lighter than ordinary cast iron pulleys, and being uniform in their construction and evenly balanced, they are suitable for running at very high speeds. Being without spokes, there is no fanning of the air and accordingly no loss of power due to atmospheric resistance. The absence of sharp edges and the fully enclosed shape also obviate the danger of accidents, and there is less injury to the belt when put on or thrown off.

IMPROVED AIR-PUMP DESIGN.

The steam turbine can approach the best reciprocating engines in point of economy only when exhausting into a high vacuum, and this fact is doubtless responsible for considerable improvement in condensers and air-pumps. The accompanying illustration shows the Fraser double-acting air-pump, which was designed to reduce clearance space to practically zero. This type of air-pump, built by Douglas Fraser & Sons, Arbroath, Scotland, is so constructed that the condensing water flows directly into the barrel of the pump without passing through inlet valves or contracted ports. The water is forced out through discharge valves covering the ends of the two cylinder sections, and the piston touches each valve alternately so that the clearance spaces are emptied com-

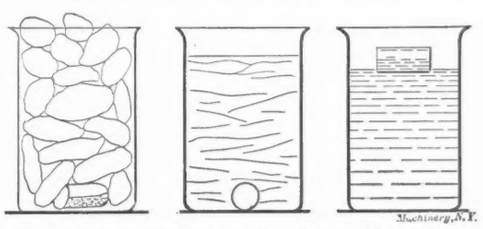


Improved Air-pump Design.

pletely each stroke, consequently there is little or no expansion of vapor behind the piston on the return stroke and every stroke of the pump displaces very nearly, if not quite, the exact cubic contents of each cylinder section.

FLOW OF PLASTIC SUBSTANCES.

It is claimed that a mushroom will grow up through the asphalt of a city street, and that such cases have been noticed. It is almost inconceivable at first thought that such a tender plant as a mushroom could break its way through the tough, sticky asphalt which requires the sturdiest blows of a laborer's pickax to dislodge. The phenomenon, however, like many other strange actions of natural forces, is capable of simple explanation. A German publication recently illustrated the action of the mushroom growing through tough asphalt by an experiment made with lumps of cobbler's wax and a cork, and the accompanying cut shows the stages of the experiment. In the first view a glass jar is shown containing a cork at the bottom, upon which are piled lumps of cobbler's wax until the jar is filled. After a period the lumps of wax will settle down and become one solid mass, as illustrated in the second view, the cork still remaining at or near the bottom. But, a still further period of time will show the cork slowly lifting



Example of the Result of Persistent Action of Small Force.

through the sticky tenacious mass, owing to the power of displacement, the cork being much lighter than the wax. This slow but sure action is analogous to that of the mighty mountain glacier which will yield to the gentlest force operating continually and in time it will be observed to follow the direction of a very slight pressure. It may take months or years to produce an appreciable effect, but the effect will surely follow. In the case of the mushroom growing through the asphalt, the pressure exerted by the growth of the fungus is extremely slight, but it is persistent and will surely displace the asphalt in time, weather conditions being favorable.

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MACHINERY

REGISTERED IN UNITED STATES PATENT OFFICE.

DESIGN—CONSTRUCTION—OPERATION.

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We solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense. All copy must reach us by the 5th of the month preceding publication.

JUNE, 1907.

PAID CIRCULATION FOR MAY, 1907, 22,711 COPIES.

MACHINERY is published in four editions. The practical work of the shop is thoroughly covered in the Shop Edition—$1.00 a year, comprising more than 430 reading pages. The Engineering Edition—$2.00 a year—contains all the matter in the Shop Edition and about 250 pages a year of additional matter, which includes a review of mechanical literature, and forty-eight 6 x 9 data sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering. RAILWAY MACHINERY, $2.00 a year, is a special edition, including a variety of matter for railway shop work—same size as Engineering and same number of data sheets.

THE FUNDAMENTAL VALUE OF EDUCATION.

Some practical men, who have been eminently successful in their line of business, and who have found success possible without any technical training, because of some superior intellectual qualities of theirs, are very likely to look upon technical training as superfluous and unnecessary, not to say harmful. There are some technically trained men, too, who seem to think that some of the things taught them at school serve no useful purpose whatever, because in their particular branch of activity they have no opportunity to use the knowledge imparted, and consequently soon forget all they once knew. This view is one that needs correction. The value of education does not necessarily always lie in the knowledge imparted, but equally much in the intellectual processes of its acquisition. The training of the mind toward clear, concentrated and logical thinking is more necessary to the engineer than are Pascal's theorem and elliptic integrals. But these latter may be a wonderful means for acquiring the qualities essential to a successful designer or engineer. They teach clear thinking, and *that* is the greatest asset of the technical man. Whether technically educated or not, the man who can analyze a problem, who can clearly define to himself all the conditions involved, he is the man who will succeed, and who will fill a useful place in the industrial machine. If technical education helps a man to acquire the habit of thinking logically, then it serves a purpose even if we disregard the value of the actual knowledge imparted. And that technical education does serve such a purpose cannot be questioned.

* * *

THIN PAPER FOR TECHNICAL BOOKS.

It is unfortunate that the occasional buyer of technical books is likely to be guided by mere bulk; he usually likes a large book for his money. Given two books, each listed at say $3.00 apiece and containing the same amount of actual matter, but one double the bulk of the other, the larger one will probably prove the faster seller, provided the matter in them is of equal worth. But when the buyer of technical books has accumulated a considerable library he begins to wish that his books were of a smaller compass for the same amount of matter; he feels in general that he would be the gainer if technical books were printed on thinner paper, in finer type and with comparatively narrow margins. It really becomes a serious matter when we consider that the average library could be reduced in bulk at least one-half and still contain the same information and in readable form.

We would like to see a reform in this matter, and no doubt most of the engineering profession who have an accumulation of valuable books, and more in prospect, would gladly see it also. The engineer's handbook is an example of the amount of information that can be crowded into small space, when there is an incentive. For example, Kent's Mechanical Engineer's Pocketbook contains the equivalent of over 900,000 words, equal to the contents of about seven ordinary 6 x 9-inch books on engineering subjects as put out by one well-known publisher. An objection to condensation is that generally the quantity of original matter available makes a very meager showing if crowded into a volume printed on thin paper in small type, hence the incentive to padding. The remedy is to let the public become educated to a liking for thin meaty volumes which do not have a bulk totally disproportionate to their importance.

We have before us an ambitious cyclopedia of mechanical engineering in twelve volumes which occupies a shelf space of nearly 21 inches. We have no doubt that the total contents of these volumes could be condensed into six volumes of the same size by the simple expedient of using thinner paper, smaller type, and narrower margins. If smaller type than the usual book type is objected to, we have only to point to the newspapers which are read daily by thousands of old and young without inconvenience. When a man has toted a small technical library around the country in a trunk for a few months, the process of elimination begins, and oftentimes really valuable books are disposed of simply because of their unwieldiness. Were technical books printed on thin paper in condensed form, an engineer could carry a good-sized library without serious inconvenience. The world at large would be the gainer and we do not believe that publishers would be the losers.

* * *

PEACE AND THE MACHINIST.

Of all the follies that the mind of man has conceived, there is none more ridiculous than the notion that the expenditure of enormous sums yearly by the nations of the earth is necessary for the maintenance of the world's peace. Of all the senseless arguments that have been used to defend this idea, few have ever been propounded more childish than one which certain of our English contemporaries have lately been advancing for the edification of machinery builders. Their argument is that men engaged in mechanical and engineering work should oppose a diminution in the present rapid increase in the supply of revolvers, rifles, machine guns, heavy ordnance and battleships, on the ground that it would be a serious blow to the prosperity of the machinery business.

Supposing the argument to be a valid one, it would still be possible to hurl volumes of sermons against the idea, considering it from a moral standpoint. This, however, we will leave to others more able in that line than we. Looking at it from a business standpoint, as our contemporaries evidently intend, it must be admitted that Old World engineering activities are so involved with the building of arms and armament that the process of separation and readjustment will be a painful one. But it is surely rather late in the day to be reminding grown men of one of the elementary principles of the science of wealth—that all wealth is wasted which is expended in any way that does not involve self-reproduction. The man who squanders an inherited fortune on yachts, servants, horses and such like, though thousands of dollars of his money pass through the hands of the tradesmen and mechanics with whom he deals, is yet impoverishing the social body to which he belongs instead of enriching it; and in the same way the nation which makes small arms, heavy ordnance and battleships, to be slowly eaten away by rust or suddenly destroyed in battle, is surely wasting the resources of its citizens. The machine tool maker, particularly, should remember that there is no business so vitally dependent on the general prosperity of the social body as his. As we have often pointed out, every manufactured article of civilized life is either the product of machinery built by him, or the product of machinery made by his machinery. So our English contemporaries must please excuse American mechanics, at least, from being disturbed over the growing peace sentiment.

OUR FOREIGN MACHINERY TRADE.

Although our foreign trade in machine tools has probably never been so large as during the twelve months past, those who are familiar with conditions in Europe believe it has reached the limit, and that with the exception of a few specialties which European manufacturers cannot make as cheaply or as well, the sales of our tools abroad are likely to decline unless a change occurs in conditions here. The problem before our manufacturers is a difficult one, because the solution is affected by so many conditions over which they have no control.

The productive ability of American mechanics is so much greater than their foreign competitors that they can largely overcome the adverse percentage of labor cost; but as the foreigners learn our methods, which they are rapidly doing, this percentage decreases, and we must reduce the difference between the foreign manufacturer's price and ours, or we shall lose the advantage in his market which our methods have up to this time secured for us. The foreign manufacturer has other things in his favor besides cheap labor—he has proximity to his market, familiarity with local requirements, a national sentiment in favor of home products with all which that implies, and in Germany the active assistance of his government.

Familiarity with these conditions caused us to write our manufacturers of machine tools and small tools, who are interested in foreign trade, for advice and suggestions that would help the situation; and from several hundred replies, representing practically every firm in our field, we have received permission to quote from a score, although the letters were not written for publication. These are arranged without regard to the size or location of the firms, and make interesting reading.

1. "It no doubt is a fact that for the last three or four years, during the period of unusual prosperity in this country, foreign manufacturers of tools have been encouraged to take up the copying of American-made machinery and tools, through the fact that American makers have not been able to take care of the demand made upon them.

"This, of course, is a most unsatisfactory condition of affairs, for there is little encouragement to the American makers to reduce prices to compete against the foreign-made machines, and not until quite recently was it necessary for us to do so; but during the last year there has been such progress made by foreigners in the manufacture of goods by American-made machines furnished for that purpose, that they are now approaching nearer to perfection, and then, of course, with the difference in the cost of labor and material in the foreign countries, they are in a position to compete.

"The subject, as stated in your letter, covers the condition of affairs at the present time, and the question the writer has asked himself a great many times is, What are we going to do about it? I must acknowledge that I have not been able to answer this question with any degree of satisfaction to myself. Pushed as all American manufacturers are to-day to complete orders that come to them without solicitation, almost, it is rather difficult for them to look even to the present, and to formulate a plan for the future is quite out of their minds at the present time.

"I presume when the time comes that American manufacturers require foreign business to keep their plants employed, the conditions will right themselves, and to do this a general reduction in the price of raw material as well as labor would be necessary, all of which at the present time is out of all proportion to the ordinary condition of trade."

2. "Our foreign customers get as good delivery on their orders as our domestic customers do on the same kind of styles and sizes. We thoroughly believe that principle to be fundamental, that one must give them the same service, and while our deliveries have been slow of late, the slowness applies to all shipments equally.

"We have no suggestions to offer in regard to any method by which the foreigners can be prevented from copying our machines or underselling us if they see fit to copy our designs, further than to get in such shape, if possible, to make the very promptest delivery on orders they send us, as we believe this counts for a great deal in the placing and retaining of business."

3. "Ever since we started to do an active European business, about twelve years ago, we have been convinced that it was only a question of time when the European manufacturers of standard tools would develop to the point where they could take exclusive care of their home requirements. In fact, the demand for our line has lasted longer than we originally anticipated.

"We consider it perfectly natural, and in accordance with the laws of political economy, that the Europeans should want to eventually become independent of us; and we believe that in spite of anything that we can do the European demand will steadily decline.

"Broadly speaking, we can see only two ways in which we can stave off the evil day. One is to develop our system of manufacture to such an extent that we can afford to meet European competition on basis of price. The other is to continue to improve our tools to such an extent that the foreigner will be tempted to pay an extra price in order to secure the latest original, rather than a home-made copy.

"We have realized all along the desirability of preserving a foreign outlet for our product, and therefore have continued to make special efforts to extend to our European agents and customers every possible consideration; thus doing our share toward fostering that feeling of confidence without which any systematic effort will fail."

4. "Notwithstanding the condition which you report as existing abroad, we do not see that anything practicable can be done to offset it so long as present conditions exist here. It is simply another instance of the bird in the hand instead of in the bush, and we doubt if any one will be prevailed upon to relinquish home effort while these conditions do exist."

5. "While American manufacturers have more than they can do at the present time, it will pay them well to look ahead and not now neglect the foreign field. We believe that every American manufacturer who desires to increase his volume of business should pay special and particular attention to the possibilities in all foreign markets.

"The most effective way, we believe, to keep thoroughly posted and in close touch with requirements is through what is often termed 'missionary work.' While it is expensive and does not always yield an immediate return, we believe that it surely pays eventually. For our business we already have two representatives in Europe who are not necessarily salesmen, but who go about separately and also with the selling representatives of our agents there, so as to become thoroughly acquainted with requirements and assist the consumers of our goods in the proper use of them in any way that they can. They also promote new trade and arrange for demonstrations of our goods in works where they are not as yet introduced, and in this way lay the foundations for substantial returns later on.

"While we knew that our agents did not promote new trade as much as they might, and that we were not taking advantage of all the possibilities, we are astonished at what we find out from the reports our missionaries are making. If all the manufacturers who are interested to a greater or less extent in foreign trade would wake up to the necessity of giving as careful attention to the foreign market as they do to the home trade, they would find it would turn out to be a great thing for them and the country at large. While missionary work managed from here is quite effective, not as much can be accomplished by it as there would be by establishing a manufactory and a selling force for pushing the goods over there in the same manner as we do at home. That there are great opportunities abroad is beyond question, and if American manufacturers want their share of that business we believe they can secure it.

"Great things could be accomplished by systematic effort, consideration and discussion of the subject. The difficulty will be in securing the interest of American manufacturers for this work, when they are so very busy at home. If they are looking ahead, however, they ought to be willing to spend a little time now on what will benefit them later on."

6. "We think the only proper method to handle foreign trade is for a member of the concern to take a trip at least once a year, getting in touch with his foreign representatives as well as with manufacturers. We feel that has been neglected by nearly all of the American manufacturers in the machine tool line during the past year or two. In fact, we believe that never at any time have they been aggressive enough regarding the foreign trade, and any move in this direction we think would be a good one, especially looking toward a future outlet for our goods when times are a little dull in this country."

7. "The writer went abroad last October and devoted his time to the study of trade conditions in England, Germany, Belgium and France, and to some extent in Italy and Spain, and was indeed surprised to discover the almost bitter feeling existing there against American manufacturers, all brought about through the neglect, or, in fact, indifference, of American manufacturers in general to the foreign market. One foreign manufacturer who has been equipping his plant with modern machinery, mostly American, showed the writer letters from certain American houses (manufacturers), in which shipments of some twenty-five or thirty machines of different makes had been promised nearly nine months before that date and had not then been shipped; and judging from the tone of the American letters, and frequent promises made of shipment, it was quite apparent that the American machinery people in question had simply neglected those foreign orders by using the machines to fill orders here at home at possibly slightly higher prices, and had not only done so once, but had kept

on doing so; and if they thought they were fooling the foreign firm by their promises they were sadly mistaken. This was only one example of the conditions which the writer found to exist in many cases which came to his notice, and in talking of this condition with an American manufacturer, after the writer's return home, he (the American manufacturer) remarked: 'Why should we ship our machines over there when we can get more money for them here?' This seems to be the thought existing in the minds of many American manufacturers at present, and has existed there for the past three years, for they see only the dollar in hand, but lose sight of the fact that a few dollars from the other side might be quite cheering to them a year or two hence.

"The writer does not feel qualified to advise as to a plan to overcome the injury already done to the American machine and tool trade in foreign countries, but thinks the best thing that could possibly be done would be to strongly urge all American manufacturers to go abroad with a view of making a study of trade conditions, for no manufacturer who is alive could go through Europe and talk with manufacturers and dealers there, also visit the principal works, without appreciating the true condition of affairs and what it must shortly lead to, in fact has already led to.

"We have always paid strict attention to foreign trade, and will give a foreign order preference any time, and have been able to work up, and not only hold, but greatly increase, our foreign trade in this way; and while it may not be necessary to give foreign orders preference over home orders in all cases, yet it is well to accord foreign orders at least equal attention.

"The writer's observations abroad disclosed to him that there are a few, too few in fact, American manufacturers who have the correct ideas regarding the way in which foreign trade can be had, and these few concerns are not only doing a very fine business abroad, but they have the respect and confidence of both dealers and manufacturers. These firms have their own representatives over there, men who are thoroughly conversant with the machinery built by the firm they represent, in fact, American mechanics who have worked at the trade in their respective shops here at home, and have been sent to Europe in the interest of their firms to work in connection with the dealers there who represent the American firms. The foreign dealer has good salesmen, but it is quite impossible for him to employ salesmen who are at the same time so thoroughly conversant with all kinds and conditions of American machinery as to be able to explain, or if necessary, as is often the case over there, to set up and operate any machine which the dealer sells; and this is just where the American representative comes in to advantage, not only for the dealer who handles the line, but also for the customer as well, but principally for the American firm; for in nine cases out of ten where an inquiry is received by a foreign dealer for prices, for example, on American boring mills, or engine lathes, he is representing three or four American firms who manufacture both kinds of tools, and each particular make has its especial merits; but the dealer has no salesman in his employ who is able to call on the customer and discuss intelligently the respective merits of each different make of machine. To be sure, he has a good general knowledge of boring mills and engine lathes, but the chances are that the customer knows just as much, if not more, about the class of machinery he wants, than the salesman does; but where an American firm has its own man over there, he is at once sent out to call on the customer, and it is needless to say that he gets the order, and at the same time, by reason of his complete knowledge of the machinery he is selling and ability to so thoroughly explain its merits, he gains the confidence of the customer; and when this is once gained it goes a long way toward establishing permanent relations, and in the writer's opinion, these few American firms who have maintained their own representatives abroad for the past two or three years, working in connection with their foreign dealers, are the firms who will continue to enjoy a large foreign business. Of course, all American firms who are doing business abroad cannot afford to maintain a representative over there, for the amount of business in their particular line would not warrant the expense; but two or three firms in similar lines might profitably combine in sharing the expense of a man to look after their interests; and the writer is firmly of the opinion that, if American manufacturers would personally investigate the conditions of trade abroad, they could not fail to see the necessity of greater cooperation with their foreign representatives, and to the end of complete cooperation, to send their own American representatives to work in conjunction with their foreign dealers. There has been too much printed about primitive methods of manufacture on the other side, about the ignorance and incompetency of the laboring classes, etc., all of which may have been true enough ten years ago and possibly may still be true in regard to some small sections of the black forest district of Germany, portions of Spain, Italy and Russia; but when it comes to the general manufacturing centers of Germany, France, Belgium or England, there is nothing primitive about either methods or workmen, and the quicker American manufacturers forget that they have ever read such stuff, the better it will be for their interests in a business way abroad; and the best way for this knowledge to be acquired is by a trip through Europe, not to study the old castles on the Rhine, nor the mountains of Switzerland, but to visit foreign manufacturers and study their 'primitive' methods, and profit thereby.

"There are firms in this country, with whom the writer has talked since his trip abroad, who really think they are enjoying a very fine foreign business, and as one manufacturer said, 'we are getting all there is in our line,' but to the writer's personal knowledge, this particular firm is losing more foreign trade every day than they now get in a month, simply because they have never deemed it necessary to make a trip over there, and also because they have, through their wisdom (?), failed to heed the advice which has been given them repeatedly by their foreign agents; and the result is that instead of getting, as they think, all the business there is in their line, the very same articles are being duplicated over there, and manufactured even better than those made here, and it is only a question of a short time when the American firm will find that their foreign business will be no more, and they will then probably condemn their foreign agents for not keeping them informed, but they will be bound to 'sit up and take notice' very shortly, and so will many other good American firms who have deceived themselves into all sorts of beliefs."

8. "Our first suggestion is that American designers and manufacturers must improve their machines in design, workmanship and producing capacities, so that by the time the present machines are copied and in process of manufacture in Europe the newer and better machines will still find sale on account of their superior qualities.

"Our second suggestion is that American manufacturers take carefully into account their ability to sell largely in foreign markets in less prosperous times than the present, and be careful not to unduly enlarge their facilities in these prosperous times, particularly when it must be done on borrowed capital."

9. "I quite agree with you that we American manufacturers have enjoyed a very prosperous business in foreign parts which, as your letter would apparently imply, may not always continue. If not, what shall we do?

"In the first place we are of the opinion that it is highly important that Americans should keep design to the front. In fact, we believe it is *the* strength of American tools abroad. For a long time we have been undersold by foreigners when they have 'caught on,' so to speak, to the excellence of our designs; but progress here is so rapid that by the time they get a machine well under way, our designs are well improved, though, as you know, the gap between us and them is rapidly narrowing. Frankly speaking, it would seem to me that, laying aside the matter of superiority in design, we must contemplate defeat in foreign parts unless our wages shall be relatively nearer to theirs. The cost of living and wages in this country are so great, compared to foreign prices, as to be more marked every year. While this feature is somewhat commented on now, it is bound to be much more dwelt upon when we have a real depression hereabouts.

"We cannot see how American manufacturers can make any move to counteract this, unless it is to have a lowering of our tariff. There are quantities of things, which enter into the purchases of the working classes, which could be bought cheaper if obtained from abroad. Now we are really talking politics, and you want practical business suggestions."

10. "We have realized for some time that some organized measure must be adopted by American manufacturers, and this we believe must be done aggressively, and we do not see how any results can be accomplished unless the assistance of this government is obtained. We believe that the government should establish a bureau to further the sale of American products abroad, especially the metal trades products, as this bureau of the government could then report to the administration, making suggestions as to corrections or modifications in reciprocal tariff arrangements to the advantage of this country, instead of leaving the question of tariff to a lot of theorists in the Senate.

"It is practically impossible for this firm to sell machine tools in Europe, with the exception of those which we make a specialty of, and which cannot be obtained anywhere else, and we have found many instances where the German machine tool builders have sold competitive tools in this country, paying the freight, insurance and duty, still obtaining the order at a lower price than we were able to quote. We likewise understand and know that a number of the foreign agents are interested in machine tool manufacturing companies in their own countries; this is naturally a detriment to manufacturers in this country."

11. "Some will think it best to favor the home trade in good times like these to the exclusion, if need be, of the foreign; others will nurse the foreign business, and even favor it somewhat, with the idea of having it when business drops off in this country. It may be possible for some manufacturers who make special machinery which, on account of its novelty, has little competition, to neglect the foreign business in these times, and still, when they need it again, be able to go on the other side and build up a trade without much trouble.

"We do not believe the regular manufacturers of machine tools can afford to do this. Our policy has always been to

treat the foreign business just the same as though it were home business. We do not favor it to the exclusion of home business, nor do we favor home business to the exclusion of the foreign; but we give it just exactly the same consideration that we do business received from this country and no more. The result is that we are taking care of our foreign agents just as well as we are our home agents, and although we are behind on deliveries, just as everyone else is, we are not treating our foreign agents any worse than the agents in this country.

"We believe that we could obtain more foreign business if we were making a special effort to get it, but as we are unable to take care of the business we are now getting and make satisfactory deliveries, we are not just at present making any special effort to get more. We believe that manufacturers who are now ignoring the foreign business they had before the boom struck us, will find it hard to get this business back again, for the machine tool builders abroad are fully awake to modern improvements in design and methods of manufacture, and that while we still lead them slightly, they will not be slow in catching up.

"When the writer was abroad three years ago, he found considerable complaint among the dealers, especially in Germany, on account of the manufacturers having done this very thing during the boom in 1900. The result was that tools made by these American manufacturers were then being made abroad, and the market had been utterly lost in certain sections for the Americans.

"We think the only policy to pursue with foreign dealers is to give them a square deal just as we do our own home dealers. We do not see how we can do any more than this without making hard feelings at home; nor do we think we should do anything else, because that would be treating our foreign agents unfairly.

"When business gets quiet in this country we shall undoubtedly make a stronger effort to get some business abroad. This we might accomplish by sending representatives from this country over on the other side to assist our agents there, as that method usually results in an increase of business.

"We do not dare to pursue this policy now, because we do not want to stir up business and take orders which we cannot fill, therefore we are following the policy of lying low for the present."

12. "You are, of course, aware of the attempt made some time ago to induce the authorities at Washington to send abroad experts in the machinery business to supplement the work of our consuls, and this in the writer's opinion will be one of the greatest helps toward an increase, or at least a continuance, of our present volume of trade abroad. Therefore anything which you can do through your publications or otherwise to create a public opinion in favor of such a move would be highly desirable."

13. "We are fully satisfied that the conditions abroad are changing very rapidly. That is, the foreign manufacturer of tools is waking up to the fact that the Americans have had a monopoly on this business for a great length of time. We have discovered to our sorrow that anything we make in the way of an automatic screw machine, and sell in large quantities in foreign countries, has been duplicated in almost every instance where we have not been protected by patents. The only solution we can possibly see to offset this condition is to keep on improving our machines and, if possible, obtain patents on everything of any consequence; but the great trouble is that it is possible in a great many cases to improve a tool in various ways and still not add anything that is patentable; and, in such cases as this, it would seem necessary for us at all times to keep on thinking of something to add to our tools, so that the parties who steal our ideas on the other side will always be trailing as regards the latest design.

"When we obtain a patent in a foreign country, especially in Germany, it is necessary, according to their patent laws, that we should manufacture in that particular country in three years from the granting of the patent. You can well understand that in order to keep up with this kind of a game it would be absolutely necessary for us to manufacture our machines on the other side. You cannot fool them by sending along parts of machines to have them assembled. You have got to show them that you are actually manufacturing in good faith in the country in which the patent has been obtained.

"Just as soon as the foreigner develops to the extent of being able to produce fully as good a tool as the American, there is no question in our minds but that it will be almost impossible for us to keep on doing business in foreign countries. The only reason, as we understand it, why our business has been so extensive is because the workmanship on American tools is much superior to that on foreign tools; but we well know that this cannot continue, as the foreigner is waking up to the fact that there is a large business to be had if he can turn out as good a tool as he is now importing. We have no great fears at this particular time that our business is going to drop off on this account; but before many years we shall certainly suffer for the very reason that in Germany, where we sell a great amount of our product, they are progressing very rapidly and manufacturing some very good tools of all descriptions at this time.

"To sum this whole matter up: It seems absolutely necessary that the American tool builders should keep on improving at all times so that their foreign agents will have something of importance to talk about; and, as we said before, in the matter of patent protection we are not so secure in retaining our business for the reason that when you design a new machine, or an attachment for same, and apply for a patent at once, should you obtain this patent in what you would call a reasonable time, there is a possible chance that you would not be in shape to market this particular tool, or attachment, for perhaps a year or more after you obtained the patent, leaving you, say, but two years in which to work the business before the foreigner could steal your ideas; and it is not always the easiest thing in the world to add new ideas to your product in order to keep up with anything of this kind."

14. "It would seem obvious that any manufacturer or dealer, for that matter, who does not look after his customers, whether they be domestic or foreign, is bound to lose them in the end, and an effort to take collective action in some way to wake up sleepy heads to their own interests would seem to be about on a par with the effect of the labor union to establish a minimum wage; that is to say, it would be hard on the part of the capable to drag along the incapable. We believe the cases are exactly parallel.

"It may not be uninteresting to state our own position with regard to trade, and when we say trade, we mean domestic and foreign both. Our position is just this, to make the best machinery we know how to make, sell it at a profit if we can, treat our customers with absolute fairness, whether they are at home or abroad, to increase our capacity so as to keep our deliveries about the same under all conditions of demand, and all of this without the slightest regard to what anybody else does or how he does it.

"To make a concrete illustration of this, we may say that we have raised our price only 5 per cent during all of this so-called boom, and this has been made to apply to all of our trade, whether domestic or foreign. We have kept our deliveries good at all times. We are making deliveries now from five weeks to ninety days from date of receipt of order, according to the size of the machine to be delivered.

"With especial regard to foreign trade we may say that we have our foreign agents all over the world. Some of them have been with us eleven years, but we don't suppose they will continue selling our American machines one moment after they can deliver machinery made in their own countries that is just as good and just as cheap; they would be very foolish if they did. We always recommend an American machine to an American if he inquires of us about it, and we cannot see that it is any crime in a German, or Englishman, or Frenchman to recommend the product of his own country as often as he has an opportunity.

"The only way we can see to hold our foreign trade and to increase it, is to make good goods, better than they can get anywhere else, make them for less money than anybody else can make them for, and to deliver them promptly."

15. "When the writer last traveled through Europe, he was convinced that the time was not far distant when the home makers would be able to supply the demand for all the standard tools. This condition, however, has not yet arisen, but it would seem as if they should be able to meet American competition in this respect. Our suggestion would be that the American makers study the requirements of the market more fully, and endeavor to supply machines which will be better adapted to meet these conditions than their regular product. Moreover it would seem advisable that American makers should affiliate themselves with selling agents who would use their endeavors to further the selling of the American product, and who would not use their connection with American firms to develop the manufacture of such tools at home. Secondly, it is desirable that American manufacturers should be allied with concerns who can and will carry a reasonable stock of machine tools for immediate delivery, and who would, if necessary, be prepared to carry a limited supply of their repair parts for standard machines.

"During prosperous times a continued effort should be put forth to secure European business, and the European market should receive as prompt deliveries as the home market. We also think that every manufacturer should insist on knowing to whom his machines are sold, in order that he may be able to supply repair parts promptly, and that there may be no delay in taking up matters regarding the operation and care of his machine."

16. "The most successful way we know of is to have good American mechanics who thoroughly understand the machine tool business, and also posted on the foreign demands, who can speak foreign languages, to go over there and sell our goods."

17. "During the past ten years about fifty per cent of our product has gone abroad, and naturally we take great interest in this trade. Under the present conditions we could

of course sell our entire output in the foreign markets, but it would not be policy for us to do so.

"In regard to the price question, we have studied this closely, and we think this question will be an important one in the foreign trade when business drops off in this country. We believe as you do that there should be some systematic effort on the part of tool builders in this country to meet conditions for the future as regards this trade. We ourselves are governed somewhat by the action of our competitors at the present time. We have always tried to sell to the foreign trade at as low a price as possible, with a fair margin of profit, not considering the condition of general business. We think this action is the cause of our success with the foreign trade."

18. "Having been associated for over twenty years with the best foreign agents, we are of the opinion that we are better represented than other manufacturers who have taken on their foreign business at a comparatively recent date. Of course the annual trips made in the past by Mr. M—— have kept us in better touch than we could possibly be by correspondence. Our past experience in handling foreign trade has taught us that foreign prices cannot be raised and lowered the way they are in this country, for the reason that most foreigners are suspicious of the motive that prompted the change, and they think if you raise your price that you are trying to 'squeeze' them, or that you don't want their business; while on the other hand if you lower them they think you intend to send another machine than the one you bid on. We have had foreign customers refuse to accept a cut of a tool, insisting on an actual photograph, saying that cuts could be altered and photographs could not.

"We have been very slow about changing our prices; when changing, we have done so only for the best of reasons. We have also shown our agents that they are getting their fair share of our production, and that while they are not getting all they would like, they understand that there is no discrimination made. About a year ago, anticipating somewhat this present boom, we looked up the average amount of business done by each agent, figured out our probable production for the next year, and then we wrote each one just what they had sold, what we could do and what they could expect, with the result that we never had a more satisfactory foreign business than we have to-day, and at the same time we have not injured our home trade.

"We thoroughly believe in foreign trade, as it has helped us out at times when other manufacturers were slack; but we think that more judgment must be used in changing prices, designs, etc., than in handling our domestic trade."

19. "It appears to me that there are four conditions which will lead the foreigner to buy our goods; cheapness, activity in pushing our goods, merit, and quality of workmanship. We cannot hope to beat the foreign manufacturer in either price or in activity in pushing the goods. Our hold on the foreign trade, then depends, in my opinion, upon quality of workmanship and merit of the designs. The foreign market would be small for the manufacturer who has not original designs and very high workmanship to offer. Of course, there may be times when the foreign work-shops will be so filled with orders that the United States will catch the overflow. This was the condition prior to 1900. Since then the foreign trade has disappeared for all except the few who had something to offer which the foreigner could not get at home.

"If the conditions in this country were such that the buying power of the dollar were more than it is now, we might be able to reduce the wages of our men without depriving them of any of the comforts which they now enjoy, but so long as we continue to support artificial prices in all the necessaries of life by a prohibitive tariff, any reduction in wages is out of the question."

20. "While the foreign countries are working hard to supply their own domestic demand, the reputation of our machine tools is such that we can command a higher price right in their own country. How long this condition of affairs will last will depend upon how far we can keep ahead of them in producing a superior article. The only way that we can maintain possession of what foreign business we have, is through superior quality and moderate price. Quality, I think we need have no fear of. Price is a question which, at the present time, seems to be considerably beyond the control of machine tool builders in this country. With pig iron selling at 50 per cent more than it did a year ago, and labor an average of 15 per cent higher, copper, brass and bronze nearly 100 per cent higher than recently, there is no option left to the machine tool builder but to raise his price.

"To illustrate this point, we call attention to one size of machine tools which we manufacture, which a year and a half ago sold for about $2,000. We have raised the price to $2,500, and the result is that our customer pays 25 per cent more for the tool; our agent makes 2½ per cent more and we make 3 per cent less profit than before the price was raised, based on the former selling price of $2,000. This is in spite of all the modern ways and means we can devise for reducing the cost of manufacturing.

"From my standpoint, I can see no excuse for the present high price of raw material in this country, excepting that there is a large demand. It will kill the goose that lays the golden egg unless relief is found, and that quickly."

The suggestions contained in these letters, and our own experience based on personal investigation in Europe, indicate the following points as most important:

1. Frequent visits abroad so as to keep in close personal touch with conditions there.
2. The same care and attention to foreign orders as to domestic.
3. Absolute adherence to promises of delivery, etc.
4. Care in carrying out shipping directions.
5. Infrequent changes in price.
6. Advancement in design, and, if possible, reduction in cost through improved methods of manufacture or otherwise.
7. Missionary work abroad by your own travelers, if your business warrants it.

To these we add our strong opinion that free raw material is absolutely essential to preserve our foreign trade in machinery.

* * *

SHORT POSTAGE ON FOREIGN MAIL.

Short postage on letters to foreign countries is a serious matter for American importers and others who would establish satisfactory foreign relations. Many complaints are made of the carelessness of American correspondents in this regard, and although apparently a trifling matter, it is one of those things that goes a long way toward fixing in the minds of those whom we would please the opinion that our business methods are quite lax. When a firm is carrying on an extensive foreign correspondence, "postage due" may be a considerable item, for when a letter is mailed to a foreign country with insufficient postage, the amount due is doubled, the recipient being obliged to pay two rates and, in effect, is fined for the carelessness of one who perhaps is a total stranger to him, having no particular claim to his courtesy. The latest complaint that we have noted in the U. S. Consular reports is that of Consul-General Samuel M. Taylor, Callao, Peru, in which he mentions a particularly aggravating incident. A Peruvian gentleman received from a business man in the United States a letter short of postage, but the letter was accepted and the postage paid. The entire subject matter concerned the interests of the American, being a letter of inquiry. A letter containing valuable information was sent in reply, in which incidental reference was made to the short postage that the writer had to pay. His American correspondent wrote a profuse letter of thanks and apology, assuring him that such an accident would not happen again, but the letter of apology was itself short of postage!

* * *

TO DETERMINE ACTUAL PLANER SPEED.

The following is taken from a catalogue describing the high-speed planers made by Bateman's Machine Tool Company, Ltd., Leeds, England: "The old practice of judging the comparative values of planing machines, by comparing their speeds on cut and return, has been found very misleading. This is because of the momentary stoppage of the table at each end of the stroke and the time lost before full speed is attained after reversal. In some machines these losses are very considerable and materially reduce the productiveness of the tool, and if such machines were sped up, the loss on reversal would be enormously increased. The only accurate means of ascertaining the earning capacity of a planer is to take the cycle time, as indicated below.

Time of cycle = time of 1 cut + time of 1 return.

L = length of stroke in feet.

T = time of N cycles in seconds.

N = number of cycles.

$$\text{Average (or earning) speed} = \frac{2L \times N \times 60}{T}$$

Thus a 42-inch by 14-foot machine completes 10 cycles in 3 minutes 56 seconds (236 seconds) when on a 14-foot stroke. Therefore, the average speed is $\frac{14 \times 2 \times 10 \times 60}{236} = 71$ feet per minute."—*American Engineer.*

ENGINEERING REVIEW.

CURRENT EVENTS, TECHNICAL AND MECHANICAL—LEADING ARTICLES OF THE MONTH.

Water wheel units of 12,000 horsepower each will, says the *Engineering News*, be used to drive electric generators in a power transmission plant at Vallecito, on the Stanislaus River, California. The water units, it is claimed, are the largest thus far attempted. The water will be transmitted to San Francisco and other large centers.

The United States Steel Corporation will build a $6,000,000 blast furnace plant at Duluth. This move is of much significance and doubtless will have a great influence on the future of Pittsburg and other Eastern plants as well. The tendency is to avoid the long haul of raw material, and to transfer the conversion operations to as near the source of material as possible.

According to *Railroad Men*, the Chicago and Northwestern Railway has decided to use fuel oil instead of coal on all its locomotives in the Wyoming district. The company is sinking wells for the production of its own oil in oil lands near Casper, Wyoming. At the present time all the coal used on that division of the road has to be hauled a distance of 900 miles.

At the steel works of the International Harvester Co., in South Chicago, an exhaust steam turbine of the Rateau type has recently been installed by the Rateau Steam Generator Co., Chicago. The exhaust steam from a reversible blooming mill engine is utilized for the turbine. The exhaust from the mill engine is intermittent, and the steam is therefore taken through a regenerator. It is understood that the installation proves that in the exhaust of an average reversible blooming mill engine there is power available to furnish from 1,000 to 1,500 K.W.

The return of the British battleship *Dreadnaught* after a cruise of 10,000 miles at an average speed of 17 knots seems to demonstrate the reliability of steam turbines for battleships. The *Dreadnaught* is the first battleship provided with steam turbines, and for this reason the trial cruise has been watched with great interest by all concerned in ship building, as well naval as commercial. While there doubtless has been a great deal of information gained during this trial cruise, it is not likely, however, that much information of value will be given to the public, in view of the policy of the British admiralty of keeping such information secret.

A concrete building in Milwaukee recently went through an accidental test which amply exhibits the stability of such construction when properly executed with good materials. The *Engineering Record* mentions that an explosion of acetylene of such violence occurred in the building that everybody within was either killed or injured, and all windows, doors and woodwork were blown to pieces. An examination of the structure revealed no crack or blemish anywhere in the concrete. As the effect of such explosion on brick and timber buildings has proven to be very destructive, it makes the showing for this concrete structure all the more creditable.

Considerable sensation was created in the early part of May by the published announcement that Sir William Ramsay, Cambridge University, England, had communicated to the Johns Hopkins University, Baltimore, the news of the discovery of a synthetic process for making copper from the elements sodium, lithium and potassium, by treating them with radium vapor. It was alleged that the resulting product was copper sulphate, which, of course, is readily "broken down" into copper. As might be expected, Sir William immediately denied the alleged discovery in positive terms, so the fond anticipation of those who would smash the copper trust are not likely to be realized immediately from this source, at least.

Commenting upon the projected new elevated railroad across Berlin, Germany, which will be constructed on the suspension principle, the *Archiv für Post und Telegraphie* gives an interesting account of the successful railway between Barmen, Elberfeld and Vohwinkle in Germany, which is constructed on this principle, and which is regarded as a daring example of German engineering skill. This suspended railway has so far proven to be one of the safest railways in the world, since no passenger has ever been either killed or injured. Over, or rather under, this suspended railway 414 trains travel every day, carrying in a year more than 12,000,000 passengers. Weather conditions do not interfere with the traffic, and the motion is singularly agreeable and noiseless. The suspended railroad across Berlin will be 7½ miles long with fifteen stations. This distance will be traversed in 22 minutes, including stops, and the fare will be a trifle less than four cents.

The new artificial rubber, called "Zackingummi," to which we referred in our engineering review in the March issue, has, according to *Stockholms-Tidningen*, proven to stand up well to the tests to which it has been subjected. The results have been particularly satisfactory when using the new material for automobile tires. At the present time more than a dozen automobiles and motor wagons in the Swedish capital are provided with tires of this kind, and the users have found the Zackingummi stronger than ordinary rubber for this purpose. It has also been used for flexible gas pipes, erasers, etc., and proven to possess all the qualities of the natural product. Large factories for the commercial exploitation of the invention are to be built this summer. The price of the new article will be materially less than that of rubber. Patents are already secured in the Scandinavian countries, France and Austria, and are pending in all other civilized countries.

It undoubtedly will surprise many to hear that Benjamin Franklin is to be one of the donors to a trade school so long after his death. However, a trade school known as the Franklin Union is to be built in Boston, and to be erected and maintained by the fund left to the city of Boston by Benjamin Franklin, which fund matured and became available for use some time ago, and which has been doubled by an endowment from Andrew Carnegie. The proposed school will be four stories high, built of brick and stone. In the basement it will contain a model boiler room, a steam and hydraulic laboratory, an electrical laboratory, an automobile laboratory, and a clay modeling room. The upper floors will be devoted to chemical and physical laboratories, exhibitions and class rooms. A large lecture hall and library will also be provided. It is expected that the school will be used mainly for evening work, thus affording an opportunity for young men employed during the day to obtain a technical education along the line desired.

The *Valve World* states that the unusual demand for structural steel in San Francisco has reached far beyond the borders of the United States, and that owing to cheap ocean freight rates Scottish producers of steel are selling structural steel in San Francisco in competition with American makers. Although the ocean freight rate is about $6.00 per ton, the Scottish steel plants are able to place the finished structural steel in California at the same price as that at which American steel mills are willing to sell theirs. The plane which American steel manufacture has reached undoubtedly permits the production of steel to be carried out as cheaply as steel can be manufactured in Scotland, inasmuch as improved machinery and modern systems and appliances in almost all cases by far outweigh the difference in wages paid in this country and abroad, and it is very safe to say that if it were not for the tariff, our gigantic steel interests would be able and willing to sell their product far below the prices now charged, without suffering from being unable to get reasonable returns on the capital actually invested in the steel business.

An interesting description of a machine for making weldless chain by the rolling process, and photographs of the product, are shown in the *Iron Trade Review*, April 4, 1907. The Weldless Chain Co. of Chicago is in possession of the patent rights of the machine, which, it is claimed, produces a chain equivalent to a forged steel chain. The chain is made directly from a bar of steel at a rate of 3 feet per second, and when tested at the United States Navy Yard a ¾-inch chain proved to be able to stand up to a strain of 7,330 pounds, which performance, although the test piece in this particular case was slightly imperfect, is even better than many test records of welded chain. The principle of operation of the machine for making the chain depends upon the simultaneous impression of four dies or rollers acting at right angles to one another, each of the rollers being beveled to a 90-degree angle. On each of the beveled faces four endless dies are cut, continuing around the entire circumference of the rolls. The chain is rolled from a round bar, and when coming out from the rolling operation, is fully finished, with the exception that it has fine metal webs on the sides, which have not been fully cut off during the forming operation. These webs, however, are easily removed by putting the chain through a tumbler. In finished condition the chain is about three times as long as the original bar.

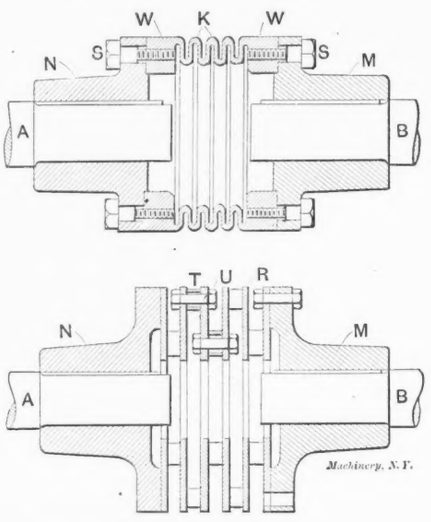
The *Industrial Magazine* calls attention to the interesting fact that concrete construction is not so new as many persons suppose. Although it is comparatively new in this country, and has not been used to any great extent during the last century in Europe, still concrete construction itself has been known at least for 4,000 years back by the ancient Egyptians and Romans, and it was more commonly used than natural stone. The pyramids, which have been the wonder of all ages, are covered with concrete. The Hebrews also knew the properties of this material, and near Jerusalem there are aqueducts and bridges of concrete, many of which are used to-day. Nearly all of these are in better condition than similar structures of brick which have been built during the past half century. There are concrete buildings in Rome which are claimed to have been in use for more than 1,400 years. In England and Ireland there are concrete castles and towers still standing, which were erected during the Roman invasion of England nearly 2,000 years ago, and as concrete possesses the quality of becoming harder with age, these constructions to-day are more solid than they were at the time when they were built. With such a record for durability, it is no wonder that modern building science should examine the merits of this building material. The idea of reinforcing concrete with steel evidently belongs to our age, and herein lies a great development in concrete work.

The experience of the Italian government with the Valtellina railroad having been particularly satisfactory, a new railroad for exclusively electric traffic, 85 miles long, is to be built between Genoa and Milan at a cost of $47,000,000. A report from Consul J. E. Dunning gives some particulars about the construction and operation of this road. The complete line will have 19 tunnels, the most important of which will be 12 miles long. The line will be double tracked, and the trains hauled by electric locomotives. These will be able to operate at a speed of 54 miles per hour on gradients of 0.8 per cent, and at a speed of 80 miles on the level. The passenger trains will be composed of three passenger cars. Express trains will run every two hours from 4 o'clock in the morning to 12 o'clock at night and make only one stop. Local trains will be run between the express trains so that in all there will be 20 passenger trains per day in each direction. The locomotives for the freight trains will be capable of pulling 30 freight cars, each car weighing 22 tons. These trains will run at a speed of 20 miles per hour on inclines, and 35 miles per hour on the level. There will be no grade crossings on the route. If this railroad, when completed, proves a success from a financial point of view, it will have demonstrated beyond doubt that electric power for regular railroad operation is not only possible, but highly desirable.

BROWN-BOVERI FLEXIBLE SHAFT COUPLINGS.

The Mechanical Engineer, February 16, 1907.

The accompanying cuts show an improved flexible coupling manufactured by Messrs. Brown, Boveri & Co., Baden, Switzerland. In the upper cut *A* and *B* represent the shafts to be connected, and *M* and *N* are coupling flanges keyed to the shafts. The coupling itself consists of a steel cylinder *K*, which has a corrugated or undulated shape produced by turning grooves alternately on the outside and the inside surfaces. There are annular enlargements *W* on both ends of this corrugated cylinder which receive bolts or studs *S* connecting the cylinder on both sides to the coupling flanges *M* and *N*. The lower cut shows a modification of this construction in which the cylindrical connecting body is composed of individual flat disks *R*,



Flexible Shaft Couplings.

which are connected to each other by distance pieces *T* and bolts *U*. The latter are so arranged that connection of two following disks is effected alternately at the exterior and the interior of the coupling. This provides for the necessary elasticity. The end disks are secured at both sides to the flanges *M* and *N*. When using the solid corrugated form the coupling flanges may, if preferable, be inserted on the shafts in the reverse way from that shown in the cut, and thus a greater length of corrugated connecting cylinder, and consequently more resilient coupling, may be obtained without altering the condition of the shaft; the corrugated cylinder in this case encloses the whole coupling.

RESISTANCE OF WOOD TO SHOCK.

Little study has been given to the resistance of wood to the action of impact loads, such as result when a locomotive passes over a wooden trestle. The Forest Service of the United States Department of Agriculture has been studying the subject at the timber-testing station at Purdue University, Lafayette, Ind., and finds that wood is more elastic under impact than under gradually applied loads. This would go to show the wisdom of locomotive engineers in taking a weakened

RESISTANCE OF WOOD TO SHOCK.

	Natural Wood.		Wood Steamed Four Hours at Twenty Pounds.	
	Static.	Impact.	Static.	Impact.
Number of tests	8	8	8	8
Annual rings per inch	7.5	7.5	6.5	7.0
Per cent of moisture	13.8	13.1	13.4	13.1
Specific gravity	0.558	0.550	0.546	0.537
Deflection in inches at elastic limit	0.31	0.67	0.34	0.67
Fiber stress at elastic limit (pounds per square inch)	6,496	15,018	6,380	13,490
Modulus of elasticity (1,000 pounds per square inch)	2,061	2,150	1,829	1,894
Modulus of resilience (inch pounds per square inch)	1.164	5.88	1.241	5.36

trestle at high speed. Air-dried loblolly pine specimens, both of natural and steamed wood, 2 by 2 inches in cross section, were tested in bending on a 34-inch span under both impact and static loadings. The moisture content was approximately 13 per cent of the dry weight, or about the moisture condition of air-dry wood. The machine and methods of test are described in Circular 38 of the Forest Service, "Instructions to Engineers of Timber Tests." The maximum deflection under a gradually applied load was 1.2 inch, and the deflection just preceding failure under impact was 1.1 inch. There is, thus, little difference between the ultimate deflection of wood under the two kinds of loading. But at the elastic limit the average deflection under gradual loading was 0.33 inch, while the average deflection under impact loading was 0.66 inch. Thus this wood possesses twice the elastic strength under impact that it does under static load. The detailed tests upon which these statements are based are presented in the table on the preceding page.

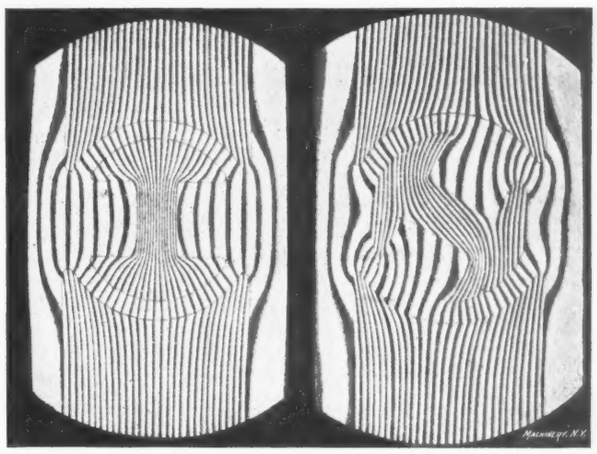
TENSILE-COMPRESSION STRESS IN REINFORCED CONCRETE.

Times Engineering Supplement, February 27, 1907.

The very considerable advantages secured by embedding small bars or sheets of steel in a mass of concrete, on which are based the various systems of "ferro-concrete" construction, were for a long time imperfectly understood, and it was not until it had been demonstrated by careful tests that reinforced concrete acquired by this means a degree of tensional resistance vastly superior in all cases to the strength of either material used alone, that this system of employing concrete became widely appreciated. The above properties depend largely upon the amount of adhesion between the steel surface and the concrete incrustation, and inventors have displayed considerable ingenuity in devising means for corrugating the steel armoring, in order to improve the grip or hold of the concrete. It has been shown that in all positions the steel under tension tends to maintain the concrete in a state of compression, and as the tensile strength of the steel enormously exceeds that of the concrete, while the latter exerts its best effects under compression, both materials are placed in a position to take any required stress under the most favorable conditions for exerting their full force. The knowledge of the actual stresses that occur in ferro-concrete is not yet complete, though important facts were made known by Considère in a series of tests conducted with prisms of concrete, some of which were formed with metal cores and some of concrete alone. He was able to show that in the case of the reinforced concrete the expansion was much less than in those test pieces wholly formed of cement, and he was thus able to estimate the enormous strain exerted on the core by the surrounding concrete, which must necessarily have been under compression, while the steel core, in order to resist expansion, must have been in a state of tension.

SEEING AND PHOTOGRAPHING INVISIBLE PHENOMENA.

The possibility of studying phenomena visually, which by their very nature are invisible, is a very interesting development of modern science. The accompanying half-tone shows the lines of induction in the magnetic field of a Siemens shuttle-wound armature in two positions. Now, of course, magnetic action is totally invisible, and the photograph is not a photograph of the actual lines of force, but of an entirely different medium which acts in an analogous manner. This view was one of the illustrations of a paper read by Dr. H. S. Hele-Shaw before the Junior Institute of Engineers, January 16, 1907. It was discovered some years ago by this versatile investigator and his collaborators that water flowing in a restricted channel follows certain mathematical laws which also apply to the distribution of lines of force in a magnetic field, the conduction of heat and the flow of electricity. After a long course of experiments it was found that the flow between thin glass plates could be made visible by the admission of bubbles of air which, following the same flow lines as the water, produced light and dark streaks or "color bands" in the water. The introduction of obstacles gave in each case a characteristic form of flow, and by ingenious arrangements a great variety of action has been imitated and made visible. In all cases the narrower lines show areas of low pressure and high velocity and the broad lines show areas of high pressure and low velocity. In the case of the armature views it will be noted that the lines of magnetic force flow freely through the middle solid part of the armature connecting the two poles, but through the air spaces there is a great increase of resistance, this being indicated by the broad bands. The change in effect due to shifting the position of the armature is illustrated in the right hand view.



Lines of Induction in the Magnetic Field of a Siemens Shuttle-wound Armature.

In this manner the magnetic flux in tooth core armatures with wide and narrow air-gaps has been investigated; also the effect of various shaped rudders on stream lines on ocean vessels, and many other objects of analogous nature. In the case of the magnetic flux distribution it has been visually demonstrated that a very narrow air-gap is not desirable, and the same conclusion has been reached by the manufacturers of electrical apparatus. At one time it was supposed that the narrower the air-gap the better the efficiency, but such has been shown by practice and theory not to be the case.

DEVELOPMENT OF THE MACHINE TOOL INDUSTRY.

Bulletin 67, Department of Commerce and Labor.

The census of metal-working machinery, 1905, prepared by Mr. Fred. J. Miller, expert special agent, gives an interesting account of the development, and a comprehensive and condensed idea of the status and possibilities of American machine tool manufacture.

American Tools in Foreign Markets.

There is hardly any manufacturing center in the world where there are not factories which are wholly or partly equipped with American built machinery. It is largely through the use of highly specialized methods of manufacture that American makers have been and are able to compete with the products of European shops. Whatever the cause underlying the superiority of American machinery, whether higher grade of labor, greater incentive for machinists to suggest improvements on the machines they use, or the fact that many machinists have become manufacturers, or for all these reasons combined, the fact remains that American tools are used extensively in foreign countries, and their value recognized. One of the greatest obstacles to the growth of the foreign trade in machine tools has been the difficulty of adjusting American tools to European shop methods, or making the European mechanic used to the American tools. The influence of one upon the other is seen in the modification of American machinery to meet European demands, and the gradual change in European shop methods to meet the requirements of American machine tools.

Specialization in Manufacture.

The most important feature of the development of the machine tool industry is the specialization in manufacture that has taken place in recent years. This specialization has grown to such an extent that there is at present not a single estab-

lishment in the United States in which a complete line of metal-working machinery is constructed. In this practice American builders have pursued a policy widely different from that of foreign builders who usually are ready to undertake the manufacture of any machinery required by a customer. The tendency in the United States is toward still greater specialization, and there are indications in Great Britain and on the continent that this plan will be adopted there also. The progressiveness of American machine manufacturers to undertake to build new and specialized machinery, however, is shown in their readiness and ability to manufacture special machinery for the bicycle and automobile industries.

High-speed Steel.

The invention of high-speed steel has had a most remarkable effect upon the development of metal-working machinery. The adoption of this steel has led to important modifications in certain metal-working machines, especially in lathes for heavy work. One of these modifications has been the redesigning of the driving mechanism of the lathe to make it capable of enduring the stress of the greatly increased speeds. Another modification has resulted from the fact that systematic tests, made to show just how fast a heavy cut could be taken, have led to a change of ideas as to what constitutes a heavy cut, and to a demand on the part of machine tool users for machines that will not only endure the higher speeds called for by the new steels, but will carry heavier cuts than formerly thought practicable. The use of high-speed steels has resulted in a considerable reduction of the cost of removing surplus metal, particularly from forgings. This has led to some misunderstanding as to the total net effect of the use of high-speed steel, the fact having been overlooked that in the construction of many kinds of machinery the chief item of expense is not the cost of taking heavy cuts, but the cost of the finishing process which involves the taking of light cuts, careful gaging, grinding, hand-scraping and other operations performed by skilled men. The cost of the finishing processes has been reduced but little by the use of high-speed steel, and in many cases they constitute the principal item of cost.

Speed Adjustment.

The use of high-speed steel has led to a much closer scrutiny of the feeds and speeds, and has thus greatly stimulated the development of speed-changing devices. Within the past five years there has come the development of a number of devices by means of which the operator, by merely shifting a lever, alters the speed without stopping the machine or shifting the driving belt from one to another position upon the pulleys, and without changing the speed of the driving belt itself. Some of the geared head developments are capable of imparting to the work not only a greater total range of speeds, but the changes from a given rate to the next higher or the next lower are by much finer gradations. Electricity has played an important part in the development of speed-changing devices. Many machine tools are driven by direct-connected motors, the motors in some being incorporated as an integral part of the design, while in others they are merely attachments. The motors themselves are arranged to run at varying speeds, and additional speed variation is obtained by gears manipulated by shifting levers.

Portable Tools.

The five years included in the census have seen a greater development in portable tools than any previous five-year period. These tools are portable in the sense that traveling cranes may pick them up and carry them where they are wanted. Instead of being constructed of such size and power as to enable them to take large castings or forgings within themselves, they are designed only to hold, direct and drive the cutting tools, the work to be operated upon being held stationary upon floor-plates. These portable tools are driven mostly by electric motors, and a number of machines may be used simultaneously upon one casting, so that boring, drilling, slotting, milling, key-seating, for instance, may all be done at one time, each operation being independent of the others. One of the latest and most interesting features of such work is the practice of setting in position both the work and the tools by means of a transit, similar to that employed by civil engineers in surveying, but made with considerably greater refinement. This enables the attainment of a high degree of accuracy where the allowable limits are stated in thousandths of an inch. These methods in turn have raised the standard of accuracy, so that in large electric generators and similar heavy work a degree of accuracy is now attained that would have been impracticable a few years ago.

Automatic Machinery.

Machines originally designed for making screws, but more recently employed for making a multitude of small machine parts and other articles, and known to the trade as automatic screw machines, have been considerably developed during the period covered by this report. These machines now handle steel bars up to 6 inches in diameter and are used for an endless variety of small parts. A better name for such machines would be automatic turret lathes, as their present function is not merely to make screws, but also to do lathe work. An important addition to the automatic screw machine is the magazine attachment by means of which castings or small forgings are fed successively to the machine. The variety of automatics known as the multiple-spindle automatic has, in particular, been greatly developed. In this machine there are now as many as five spindles, each holding and driving a separate bar of stock to which the cutting tools are presented simultaneously for action. This means that a piece of work made by as many as five distinct operations may be completed on this machine in the time required for performing the longest operation, because the tools used for performing the four shorter ones complete these before the operation requiring the longest time is done. In another machine of the automatic class which is still in the process of development, compressed air is used for moving the various parts of the machine in order to present the tools consecutively to the work and for the motions necessary for cutting operations. The extreme speed of action of air, as compared with the mechanisms ordinarily employed for this purpose, enables the motions usually designated as idle motions to be made much more quickly than is otherwise possible, and thus the time consumed in the withdrawal of one tool and the presentation of another is greatly reduced. Such improvements as these, however, do not materially reduce the labor cost of producing the work, but they reduce the cost by giving a greater product with a given investment in machinery and tool equipment and within a given area of floor space occupied. This reduction forms in many cases a considerable proportion of the total cost.

Compressed air seems likely to be used very extensively as machine tools are developed. The facility and rapidity with which it can be conveyed and its small mass make it well adapted for use in metal-working machinery. In cases where its extreme rapidity needs checking, a check is applied by the use of a body of water or oil which is forced by the air pressure through a restricted opening, and which in turn acts upon the mechanism to be moved. The liquid, by resisting sudden changes in its rate of flow, regulates the speed of the motion.

Grinding Processes.

The process of grinding, which was formerly applied only to parts to be finished true to size, when such parts were made of steel and hardened, has of recent years been developed and applied much more widely than before. It is now used for finishing cylindrical parts of all kinds. Marvelous results in grinding have been obtained by applying great power to driving a relatively large and heavy abrasive wheel which at every turn is made to sweep over the work the full width of the wheel. For instance, in refinishing locomotive piston rods that have become badly worn, a special grinding machine of this kind does the work more quickly, and at the same time with greater precision, than possible by any former methods.

Interchangeable Manufacture.

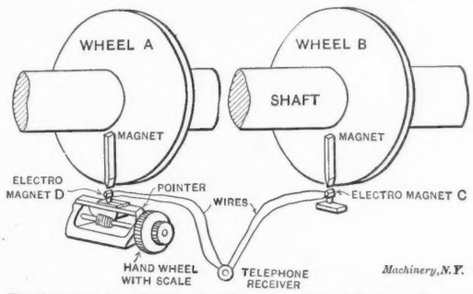
As a result of the specialization in machine tool manufacturing, interchangeability has become an adopted policy. The extent to which this plan is used in a given shop depends, of course, mainly on the number of identical machines to be

built at one time. On account of the different conditions in different shops in regard to the mass of production a great difference in practice exists. For instance, shops building large lathes in small numbers, for which tools and fixtures are more costly, soon reach a point at which the proportionate cost of tools becomes prohibitive, and in such cases it does not involve any saving to build on the interchangeable plan. However, interchangeable manufacture in the production of metal-working machinery is one of the most prominent, important and interesting features of the business as now carried on. Even some of the very largest machines which a few years ago were built one at a time, and only to order, are now manufactured in considerable numbers by the aid of special tools and fixtures, and many, if not all, have their parts interchangeable.

TORSIOMETERS AS APPLIED TO THE MEASUREMENT OF POWER IN MARINE TURBINES.

Archibald Denny, in *Mechanical Engineer*, April 6, 1907.

The writer, in this article, describes the difficulty met with in measuring the horsepower delivered by the steam turbine. The approved method of gaging the power delivered by reciprocating engines is by computing it from indicator cards. This is manifestly impossible with the turbine. In small machines the power may be absorbed by the prony brake or some equivalent mechanism, and thus weighed; in direct-connected electrical units the power output may be calculated from the readings of the voltmeters and ammeters. In larger machines, however, and particularly in the case of the marine turbine, none of these plans work. The engineers connected with the writer's firm finally hit upon the plan of using the angular flexure of the shaft, as measured between



Torsiometer Applied to the Measurement of Turbine Power.

two definite points in its length, as a measure of the torque transmitted. Knowing the torque and the revolutions per minute, the horsepower could be obtained directly.

The cut above shows the first practical solution. Two gun-metal wheels *A* and *B* were fastened to the shaft at a definite and known distance apart, the distance being as great as possible. On each wheel a permanent magnet, with a sharp chisel-shaped edge, was fixed radially at the periphery of the wheel, and with the sharp edge parallel to the shaft. At one end a soft iron electro-magnet *C* wound with fine wire, similarly chisel-shaped, was fixed, so that the moving magnet passed directly over the electro-magnet once in each revolution. At the other end a similar electro-magnet *D* was mounted on a threaded sector, and wires from these electro-magnets were led to a differentially-wound telephone receiver. If the shaft revolved without transmitting power, the permanent magnets passed these electro-magnets simultaneously, and currents of electricity generated in each coil passed through the telephone receiver, but the currents being equal and opposite no sound was heard. When the shaft transmitted power, the permanent magnets passed the electro-magnets at different times, and hence a sound was heard in the receiver. By turning the hand-wheel shown in the diagram, a new position of silence could be obtained, when it was evident that the two permanent magnets were again passing the electro-magnets simultaneously, and the amount of torque could be ascertained from the reading of the sector screw.

A later development of this idea was devised which allowed the measurements to be taken in a quiet cabin in any part of the ship instead of necessitating the operator's presence in the more or less noisy tunnel shaft, where there was some possibility of error in interpreting the sounds in the telephone receiver. This method retains the chisel-shaped magnets, but replaces the electro-magnets with a pair of specially wound "inductors" under each wheel, these inductors being so arranged as to permit different portions of their arcs to be active, giving thus the equivalent of shifting the electro-magnet *D* by the hand-wheel. This shifting of the active portion of the inductor is done by switches in the operating room, and does not require the presence of the operator in the tunnel.

The original solution of the problem, earlier than that shown in the cut, was by the obvious method of using on the disks contact points, which struck a fixed point in place of electro-magnet *C*, and an adjustable magnet point in place of electro-magnet *D*. As each contact came around, the circuit was closed, and a sharp click was heard in the telephone receiver. When the hand-wheel was so adjusted that the clicks were simultaneous, the amount of distortion would be read from the graduated disk. While this worked very well on the factory line shaft where it was first tried, at a speed of about 120 revolutions per minute, it failed to be of any use in taking measurements on the side shafts of the "Queen Alexandra," where the speed was over 700 revolutions per minute. Under these circumstances no certain sound could be obtained. It was impossible to be quite sure of the exact point at which the make and break took place, so that the apparatus was useless.

The testing of the shaft to get the torsion scale, previous to its being fitted on board, is done by fixing rigidly one end of the length of the shaft to be used for the trials, and at the other end fitting a lever; this is loaded with weights so as to get the scale or torsion moment. For turbine shafts, which are small in diameter as a rule, this is not a serious operation; nor, indeed, have we found it so even for larger ordinary twin-screw shafts, although, of course, the weights used have to be much greater. We have tested all the shafts for the turbines and other vessels on which we have used these instruments, and we find that the torsion is given very closely by the following formula:

$$\theta^\circ = \frac{W\,R\,L}{K\,d^4}$$

where

θ° = angle of torsion in degrees.
$W\,R$ = foot-pounds turning moment.
L = length of shaft in feet.
d = diameter of shaft in inches.
K = coefficient.

K may be taken at 140 for mild steel shafts where there are no couplings, or, if there be any, by deducting their length from the length of shaft twisted; that is, we assume that the couplings do not twist. It is, of course, better to test each shaft independently, but the error would not be great by using the formula, probably not 1 per cent either way.

MATERIALS AND CONSTRUCTION OF PUMPS FOR USE WITH VARIOUS LIQUIDS.

B. Björling, *Engineering Review*, April, 1907.

When purchasing a pump there are many things that must be considered, as, for instance, the quantity of liquid to be pumped, its nature and chemical properties, and whether the liquid is clean or contaminated with sand, mud, or any other impurities of this class that will wear a pump piston or plunger very quickly. For these reasons, to decide what class of pump and of what material the pump should be made, also what class of valves and what material they should be made of, are the most important considerations.

Materials and Design of Pumps for Various Liquids.

Tar and Ammoniacal Liquor.—All parts coming in contact with the liquid must be of cast iron.

Sewage.—Cast iron as a rule should be exclusively used.

Vinegar.—Gun metal or phosphor bronze should be used. If the vinegar is extra strong, antimony should be used as an alloy with lead.

Acids.—For strong acids, single acting plunger pumps made of earthenware, stoneware, glass, gutta-percha, or cast iron

lined with gutta-percha are necessary. For these pumps, all the packing in boxes and gaskets should be made with asbestos. A good construction is to make the barrels of the best glass, bored and polished true and parallel. The top and bottom chamber are made of lead or an alloy of lead and antimony. This construction is advisable also for alkaline fluids. Double acting air pumps operating by displacement may also be used.

Beer.—Bucket pumps or wing pumps made of gun metal may be used.

Benzine, Benzole and Creosote.—Double-acting piston pumps of cast iron may be used, with working barrels made of gun metal for small pumps, and cast iron lined with gun metal for large pumps, the pump rods to be of Delta metal.

Bleaching Liquids.—Use triple barrel bucket pumps of cast iron, with gun-metal lined bearings.

Dyes.—Double-acting piston pumps of materials depending on the chemical properties of dye to be pumped.

Milk of Lime.—Pumps of any type made entirely of gun-metal.

Naphtha.—Pumps of any type made of cast iron throughout.

Vegetable Oils.—Gun metal should be used.

Petroleum and Similar Mineral Oils.—Cast iron must be used.

Salt Water.—Any type of pump, but all parts must be made of gun-metal. A good alloy is as follows: copper, 8 parts; tin, 10 parts; zinc, 2 parts.

Sugar Solution and Treacle.—Use double-acting piston pumps or single, double or triple barrel plunger pumps, all parts being made of gun metal. Semi-rotary or wing pumps may also be used.

Wine.—Same as for sugar.

Hydrochloric Acids.—Parts must be made of Hargreave and Robinson's patent white metal, or the following alloy: lead, 1 pound; tin, 1 ounce; antimony, 1 ounce. These three metals must be quickly and intimately mixed just before casting.

Materials and Design of Valves for Pumps Handling Various Liquids.

Ammoniacal Liquor.—Valves should be of the miter type, made of cast iron, or mechanically moved piston valves; slide valves may be used, but they are not as good.

Anthracite Oil.—Same as for ammoniacal liquor.

Benzine, Benzole and Bilge Water.—Miter valves of gun-metal. If the height of lift is small, gun-metal balls may be used.

Beer and General Brewery Use.—Any type of valve will do, though clack valves are sluggish in their actions, allowing considerable slip. The valves should be made of gun-metal.

Creosote.—Cast malleable clack or miter valves should be used.

Gelatinous Fluids.—If not containing acids, gun-metal clack valves should be used. If acid is present, a large proportion of lead should be used in the gun-metal alloy.

Glutinous Fluids.—If of thick consistency, mechanically moved piston valves, cast iron clack valves, or ball valves will answer nicely. If the fluid is thin, cast malleable miter valves may be used.

Hot Water.—Gun metal valves of the miter type are best.

Warm Water.—India rubber disk valves, specially prepared, or vulcanized fiber manufactured for the purpose.

Milk of Lime.—Gun-metal clack or ball valves.

Naphtha.—Cast iron or cast malleable iron miter valves; the latter are the best.

Vegetable Oil.—Gun-metal miter or clack valves.

Paper Pulp.—Cast iron ball valves are best and cheapest. India rubber has been recommended, but it is expensive and wears out quickly.

Treacle and Sugar Solution.—Clack valves or mechanically moved piston valves of gun-metal.

Tan Liquor.—Gun-metal bell or clack valves. The alloy must possess a great proportion of lead to be immune from the tannic acid contained in the liquor.

Tar.—Pumps for this substance are best fitted with mechanically operated piston valves, or miter valves made of cast malleable iron.

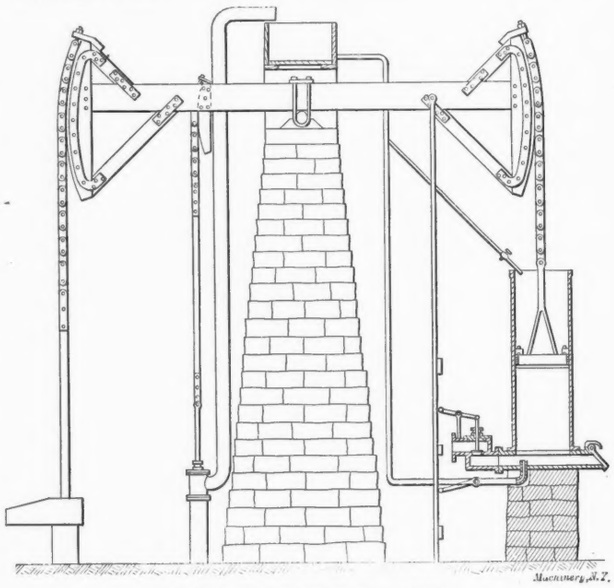
It is important to know that where the valve is of metal, both the surfaces in contact on the valve and seat must be made of the same material, whether it is a pure metal or an alloy, otherwise an electrolytic action will take place which will eat away the metal. Miter valves and others with perpendicular lift should have all the ribs and guides placed at an incline from the perpendicular, so that water in passing through will give the valve a gradual circular motion, tending to keep the beat perfect and prevent the formation of grooves. An inclination of ½ inch in 6 inches is enough for small valves, increasing to 2½ inches per foot for the largest sizes.

THE DIARY OF A MACHINIST IN 1760.

Alonzo G. Collins in *Power*, April, 1907.

After describing a holiday jaunt of a party of engineers through the old coal and iron districts of England in search of samples of the engineering works of Newcomen or Watt, the writer tells of the finding of an old atmospheric engine in a rough, thicket-grown field on property belonging to the Earl of Stamford and Warrington. A sketch of the engine is shown below.

The cylinder is of cast-iron, twenty-seven inches in diameter, and about six feet stroke. Steam entered at the bottom of the cylinder, and after the induction valve had been closed the steam in the cylinder was condensed by a jet of water injected into it, thus forming a vacuum under the piston, when the atmospheric pressure on the top of the piston forced it down; on the induction valve being again opened, the condensed steam and injection water were blown out by the entering steam.



Old Atmospheric Engine from 1760.

It must be understood that the pump end of the lever, due to the weight of the pump-rod, is heavier than the steam end. This is made purposely so, as owing to the flexible connection, the steam pressure cannot raise the steam end of the beam, the only purpose of the steam being to assist, by its condensation, in forming a vacuum under the piston. All of the work is done by the pressure of the atmosphere on the upper face of the piston, and as one or two pounds of steam pressure was ample for this purpose, and was as much as was usually carried, the excessive lead given the steam valve by the valve gear shown was not detrimental. On the upstroke of the piston it was absolutely necessary to permit the vacuum to be formed before the piston reached its upper limit of travel. This was in order to overcome the momentum of the heavy pump-rods in their descent and bring them to rest before the beam should strike the stops.

Mr. Reynolds tried to imagine how those early engineers contrived to do their work with tools and facilities that must have been crude in the extreme. He determined to prolong his vacation and make a tour of investigation. At Coalbrookdale in Shropshire, it was said a number of Newcomen pumping engines had been built at the iron works owned by the Brothers Darby. He had very little difficulty in locating the

successors of the old Darby works, and was highly pleased to find that his ancestor, Richard Reynolds, had been a manager of the old works at about 1760. This at once gave him a standing with the proprietors, who gave him the privilege of searching through a mass of old records and drawings. He was rewarded by finding a journal of one of the old-time workmen, who had spent his spare time setting down his experiences. The introductory pages of the diary were missing. The first whole entry was an account of the making of a steam cylinder, as follows:

"Began this day to scour the bore of a great cylinder of a fire engine for drawing the water from the coal pit at Elphinstone, of a bore twenty-eight inches across, and in length nine feet, the same being cast of brass after much discouragement, and the spoiling of three before, which made us of much doubt if we could ever succeed in a task of such great magnitude; but being, by reason of the extremity to which the proprietors of the pit were at, having to employ more than fifty horses to discharge the water thereof, much urged to persevere, we give great gratitude to Almighty God, who hath brought us through such fiery tribulations to an efficient termination of our arduous labors.

"Having hewed two balks of deal to a suitable shape for the cylinder to lie therein solidly on the earth in the yard, a plumber was procured to cast a lump of lead of about three hundred weight, which being cast in the cylinder, with a dike of plank and putty either side, did make it of a curve to suit the circumference, by which the scouring was much expedited.

"I then fashioned two iron bars to go around the lead, whereby ropes might be tied, by which the lead might be pulled to and fro by six sturdy and nimble men harnessed to each rope, and by smearing the cylinder with emery and train oil through which the lead was pulled, the circumference of the cylinder on which the lead lay was presently made of a superior smoothness; after which the cylinder being turned a little, and that part made smooth, and so on, until with exquisite pains and much labor the whole circumference was scoured to such a degree of roundness, as to make the longest way across less than the thickness of my little finger greater than the shortest way; which was a matter of much pleasure to me, as being the best that we so far had any knowledge of; but I was busy casting about in my mind for means as to how it might be in future made better, and I reckoned, for one thing, that I would so fashion the iron bars to which the ropes were tied, that they might be laid in the cylinder, and the lead cast on them, and so fasten them firmly."

The greater part of the writing for the next few pages was so faded as to be undecipherable, but it seemed to refer to the construction and fitting of the minor parts of the engine. Further on was the following account of the erection of the engine at the mine:

"The carriage of the engine to the coal pit was a most difficult matter; the wagon on which was the cylinder, being of insufficient strength, was often broken, and in the low places of the road we had often to put twelve sturdy horses to it, but by perseverance and our great ambition it was at last at the end of our journey with no serious mishap.

"We had at first been at some discouragement about the pumps, as we had a very imperfect notion of them; but, succeeding in having the assistance of several admirable and ingenious workmen of Birmingham, we came to the method of making the pump, valves, clacks and buckets in a very superior manner; and they being now arrived, I put some of the workmen to set them in their place in the pit, fashioning strong timbers at the mouth of the pit, and otherwheres, as I judged might be wanted for the proper supporting of it, with the mouth of the pump so high from the ground that the water might find its way to get clear of the pit.

"The great pillar I made eighteen feet long in a direction crosswise of the great lever, and nine feet the other way, at the bottom, inclining the sides, so that it should be four feet square at the top and twenty-six feet tall from the ground; it was built in the firmest manner and solid, course by course, with thin lime mortar, of lime that had not been too long slaked; at the top I set stout iron bars, the stones set around them, with screws on the end, by which to fix the gudgeon blocks solidly. On the other side of the pillar from the pump I set off to each side, lengthwise of the great lever, two stout stone walls on which to build the cylinder beams.

"It had formerly been the custom to place the cylinder over above the boiler; but this had been so troublesome by account of the great straining and jumping of the cylinder, by the great force of the steam, causing the divers joints to leak, and spoiling the stone walls of the furnace, although built ever so solidly, that I made shift to place the boiler a little distance away and to convey the steam to the cylinder by a copper pipe, which by reason of its elasticity would jump with the cylinder and thus, I reckoned, would not so soon spoil the joints.

"I then set the plumbers and coppersmiths to fashion the boiler, with great sheets of copper for the bottom, where the fire was, and similar sheets of lead for the top, which, being preserved from the fire, would not so readily be spoiled.

"The sheets of copper were set with the border of one sheet over the border of another, with hacks or cogs so cut in them as to lock one with the other, and soldered with spelter, like coppers for brewing, until there was one monstrous sheet, which the workmen reckoned large enough for our needs. They then with huge hammers and a mighty din so contrived their blows as to bend the copper to a half circle, like unto half of a globe, with the border turned out to shape a flanch, to which the lead, being similarly shaped, was made firmly solid, with putty between to stop the steam and bars of iron above and below, by screw-bolts. It was a task of greater magnitude than any we had yet undertaken, but with rare skill the ingenious workmen found means for overcoming our difficulties in a most admirable manner.

"Before the boiler could be set in its place it was needful that the cylinder should be got to its place, as otherwise there would be no room for it to pass. This task I desired to take in hand myself, as the other workmen were timorous about how it was to be got up, and a stout heart as well as a nimble body were needed if we were to have no mishaps. So a skilled woodsman fashioned as I directed some round logs of wood, truly round and straight, and others fashioned a sort of frame or cradle of massive timbers in which the cylinder might lie at ease, and the round logs on the ground beneath all, so that it was as if the cylinder was on a wagon, but low down, so that there was but small risk of its overturning; and so, with many sturdy men pulling at ropes in front and others with stout pries pushing from behind, it was at last got between the stone walls on which it was to rest.

"I now must set it on its bottom, upright, which I accomplished by lifting the top end with pries as far as the purchase might go, and, with strong timbers under it, hold it so until a new purchase could be had for the pries, and so on, until it was almost upright, when I fixed ropes to the top whereby some stout men could hold back and thus deter it from overbalancing from its momentum when it came upright, which it came near doing, as the men were caught unawares and were fair dragged some distance; but a shout from me put them on their mettle, and it got no further.

"It was now to be lifted about six feet, to get it to where the flanches on each side could sit on the cylinder beams, and this seemed the most perilous task of all, as it stood so tall and slender, as though a strong wind would suffice to overturn it. I contrived to do it, however, by means of two pries on opposite sides of the cylinder, under the bottom flanch, and four ropes from the top, with some sturdy men to pull four ways to keep it upright, whereby lifting on the pries steadily and sedately, as far as the purchase would go, and by building up with planks laid evenly under the flanch, between the inner ends of the pries, the cylinder was held up until a new purchase was made for the pries, and so on; and I was much pleased to have it go so smoothly.

"It was fairly the easiest part of it, and it was done so much speedier than I deemed possible, that I was constrained to let the men lie by for the rest of the day, as a token of good will for their nimbleness.

"The joint between the cylinder and the bottom I made firm with lead, beaten thin where the space was slim, so to match the unevenness of the flanches, and after the bolts were screwed firm, by beating the flanches with hammers and warming with a small fire, to soften the lead, I at last got it so that it was stauch with the cylinder filled with water; the other joints in the pipes, and so forth, I made firm with putty."

After describing the making of the walking beam and its gudgeon, he says:

"I now perceived where I had been at fault through my ignorance, in that I had supplied no place for the cistern for the cooling water, which must be on a tall place to cause the water to enter the water case speedily; but I contrived some timbers above the great lever, on the top of the great pillar, which did answer very well, but I had a very imperfect knowledge as to how I should get the water to it, and cast about to find some brook to back up by a dam, but found nothing to my liking, until one of the workmen contrived a little pump with clacks and bucket, which should derive its water from the top of the great pump.

"I fashioned a small curve on the side of the great lever, half-way between the end and the middle, whereby with chain and pump-rod to give motion to it, and a lead pipe to convey the water to the cistern, also a lead pipe from the bottom of the cistern to the water case, and a branch pipe to discharge water on top of the piston to stop air from going in the cylinder, with a cock in each to regulate the water."

* * *

According to a statement made by the *Mining Reporter* the cost of assembling all the raw material for making iron at Birmingham, Ala., is 77 cents per ton, which is the lowest figure ever reached either in this country or abroad.

ON THE ART OF CUTTING METALS.—6.*

FRED W. TAYLOR.

PRESSURE OF THE CHIP ON THE TOOL.

In 1883 in the works of Wm. Sellers & Co., of Philadelphia, a series of experiments was made by Messrs. Wilfred Lewis and John Bancroft with a dynamometer, in which the pressure of the chip upon the lip surface of the tool was measured. These experiments showed that for steels varying greatly in hardness, and consequently in their cutting speeds, the variation in the pressure of the chip upon the tool in no way corresponded either to the hardness of the steel or to the speed at which it could be cut. A further study of the results of these experiments indicated also that there was no clearly defined and traceable relation between the tensile strength or the crushing strength of steel and the cutting speed. These results agreed accurately with the observations which we had made in our many experiments on cutting speeds, namely, that lathes, boring mills, etc., are able to pull about as heavy cuts with hard as with the soft steels, although there is a very great difference between the cutting speeds of hard and soft steels. Having established this important fact to our satisfaction, and having through these experiments obtained sufficient data for properly designing machine tools as to the power required to cut metals, no further experiments were made by us in this line until the year 1902, when the subject was again more carefully investigated through dynamometer experiments in the shop of Wm. Sellers & Co.

The results of our experiments show that no law can be established or formulated for cutting steel which expresses either (*a*) the relation between cutting speed and the pressure on the tool; or (*b*) the relation between cutting speed and the tensile and crushing strength of the metal to be cut.

Relation between Tool Pressure and Cutting Speed, Etc.

Although the tensile strength of soft steels is much lower than that of hard steels, yet in many cases it requires more foot-pounds of energy to break, by pulling apart in a testing machine, a test bar of low tensile strength, than one of high tensile strength. The reason for this is that the percentage of stretch or extension in the soft steel bar is in most cases much greater than that in the hard steel. When we consider the fact that throughout the time that a test bar is stretching, all of the grains inside of the bar are continually flowing, moving, or sliding past one another under what may be called very heavy internal friction, it becomes clear that in spite of the fact that the pull or power required to cause flow in the grains or crystals of the soft steel is less than the pull required to move the grains of a hard steel bar, yet the greater distance through which the grains of the soft steel continue to flow more than makes up for the difference of tensile strength in the final sum total of energy expended.

In tearing a chip from a bar of steel, the grains or molecules of the metal of the chip are caused to flow past one another under very severe compression for a considerable distance, so that the thickness of the layer of metal being removed is double in the chip what it was originally in the forging. In the case of a chip torn from soft metal, the movement or flow of the grains of the chip past one another is much greater than in the case of a hard chip. In other words, a soft steel chip is thickened up in cutting much more than a hard steel chip.

Thus, in cutting a chip, the total energy expended and the pressure of the chip on the tool are in many cases greater with a soft steel than with a hard steel. In cutting soft steel, owing to the fact that it thickens more than the hard steel, the chip bears upon the lip surface of the tool over a much larger area than in cutting hard steel, and although undoubtedly the intensity of the pressure on any one small spot on the lip surface of the tool is greater in cutting hard steel than in cutting soft steel, yet the larger area which is under pressure with the soft steel chip more than makes up in many cases for the difference in the intensity. Therefore, frequently a heavier total pressure is produced with the soft steel than with the hard.

The pressure of the chip on the tool is doubtless greater,

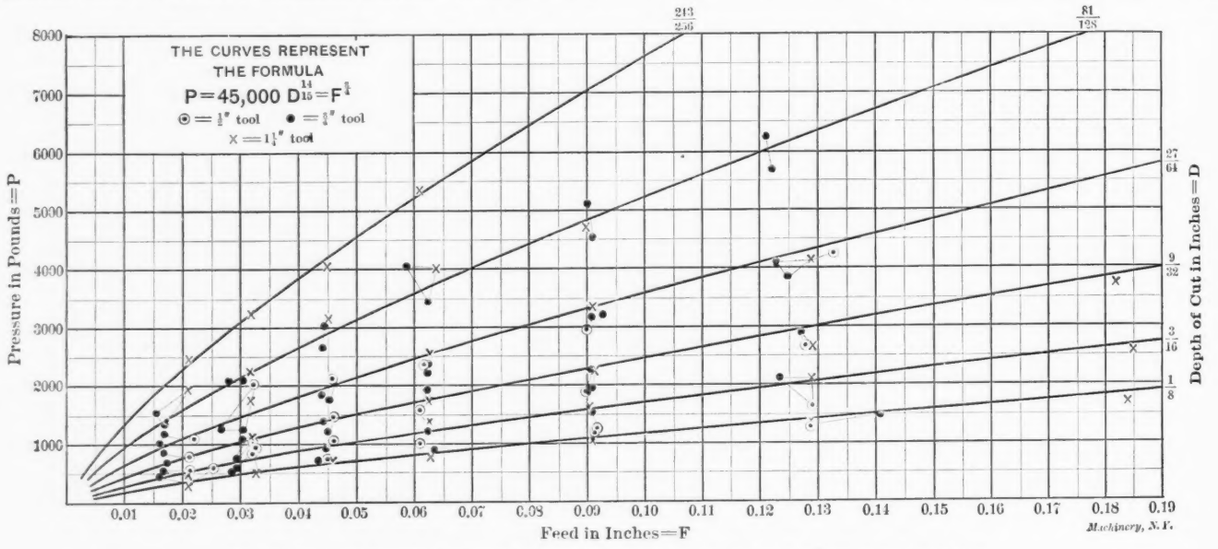


Fig. 45. Diagram showing Pressure on Tool with 1-2, 3-4 and 1 1-4 inch Tools Cutting Cast Iron.

the finer the quality of the metal which is being cut, *i.e.*, in metals which combine both a high tensile strength and a comparatively large percentage of stretch; such, for instance, as the fine qualities of low phosphorous steels which have been most carefully worked in forging, or the thoroughly oil-tempered and annealed gun forgings, or high grades of tool steel, in all of which exceedingly high combinations of tensile strength and stretch are attained. And again, it should be noted that although the pressures on the tool are high in these fine qualities of steel, yet the cutting speeds are by no means proportionally slow. The slowest speeds are to be found in cutting chilled iron or more or less hardened steels, which generally have an exceedingly low percentage of stretch and also comparatively low pressures on the tool.

Kind of Metal.	Carbon, per cent.	Tensile Strength in tons (2000 lbs.)	Percentage of Stretch.	Pressure of Chip on Tool in tons (2000 lbs.)	Cutting Speed in feet per minute.
Steel forging.....	0.50	52	14	168	41
Steel roll.....	0.55	51	8	128	35
Steel car wheel casting.....	0.82	48	3	92	22

An illustration of this will be seen in the table above, furnishing a comparison of three pieces of metal. In the first line will be found a forging consisting of a good quality of hard steel, and in the second and third lines a steel roll and a car wheel casting.

The percentage of carbon of this forging and roll are about

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the same, and the tensile strengths of all three are also about the same. On the other hand, the stretch of the roll is only a little more than one-half that of the forging, showing an inferior quality of metal. The casting has a still lower stretch, and is of still lower quality, because it has not received work under the hammer. And this falling off in the quality of the metal indicated by low stretch is also accompanied by a falling off in the pressure of the chip upon the tool, the casting having only 92 tons, the roll having only 128 tons, while the forging has 168 tons pressure. Thus we see that an inferior quality of metal is accompanied by a lower pressure upon the tool. If the metal in the casting had been forged, its tensile strength would probably have not greatly increased, but it would without doubt have had a very materially higher percentage of stretch, and the pressure on the tool would have increased accordingly.

The car wheel casting, which gives a pressure on the tool of only 92 tons per square inch sectional area of the shaving, has a slower cutting speed than any of the other samples of steel which were cut, and yet it has the lowest total pressure on the tool of any steel. This is an excellent illustration of the fact that the hardness in steel which causes a low cutting speed is not accompanied by the highest pressures on the tool. On the other hand, this steel casting has only 3 per cent of stretch and it is undoubtedly this low percentage of stretch which accounts for the slow cutting speed.

To summarize: (*a*) In cutting hard metals, the intensity of the pressure per square inch of the lip surface of the tool which comes in contact with the shaving is much greater than in cutting soft metals; (*b*) the center of pressure is much closer to the cutting edge; and (*c*) the section of metal directly below the center of pressure is smaller for carrying the heat away.

All of these conditions which tend greatly toward lowering the cutting speed are brought about not so much through the greater crushing strength of hard steels as through the smaller percentage of stretch in hard steels, *i.e.*, a smaller capacity for flow.

Pressure of the Chip on the Tool in Cutting Cast Iron.

A. The total pressure of chip on tool in cutting cast iron of the different qualities experimented upon by us varies between the low limit of 35 tons (2,000 pounds) per square inch sectional area of chip for soft cast iron, when a coarse feed is used, and 99 tons per square inch sectional area of chip for hard cast iron, when a fine feed is used.

B. In cutting the same piece of cast iron, the pressure of chip on the tool per square inch sectional area of chip grows considerably greater as the chip becomes thinner, and slightly greater as the cut becomes more shallow in depth. The following are the high and low limits of pressure per square inch of sectional area of the chip when light and heavy cuts are taken on the same piece of cast iron.

Depth of cut, 1/16 inch, × feed, 0.0328 inch. = Total pressure per sq. in. sectional area of chip, 128,000 lbs.

Depth of cut, 3/64 inch, × feed, 0.1292 inch = Total pressure per sq. in. sectional area of chip, 75,000 lbs.

TABLE I. PRESSURES OF THE CHIP ON THE TOOL IN CUTTING CAST IRON WITH STANDARD TOOLS, CLEARANCE ANGLE 6 DEGREES, BACK SLOPE 8 DEGREES, SIDE SLOPE 14 DEGREES.

SOFT CAST IRON

Tensile Strength, 12400

Chemical Composition
Combined Carbon
Graphite
Manganese
Silicon, 1.7 per cent
Phosphorus
Sulphur

HARD CAST IRON

Tensile Strength 24000
Silicon ..... 1.2 per cent

FORMULA $\left(69{,}000\ D^{\frac{1}{2}}\ F^{\frac{1}{2}}\right)$

PRESSURE IN POUNDS IN CUTTING SOFT CAST IRON FIGURED BY FORMULA $45{,}000\ D^{\frac{1}{2}}\ F^{\frac{1}{2}}$

COMPARE THESE PRESSURES WITH THE EXPERIMENTAL PRESSURES IN THE FIRST COLUMNS OF THIS TABLE

DEPTH OF CUT IN INCHES	1/2" TOOL				3/4" TOOL				1 1/4" TOOL				1" TOOL				FEED IN		PRESSURE IN POUNDS	
	EXPERIMENT NUMBER	FEED IN INCHES	PRESSURE IN POUNDS ON TOOL	PRESSURE IN POUNDS PER SQ. IN.	EXPERIMENT NUMBER	FEED IN INCHES	PRESSURE IN POUNDS ON TOOL	PRESSURE IN POUNDS PER SQ. IN	EXPERIMENT NUMBER	FEED IN INCHES	PRESSURE IN POUNDS ON TOOL	PRESSURE IN POUNDS PER SQ. IN	EXPERIMENT NUMBER	FEED IN INCHES	PRESSURE IN POUNDS ON TOOL	PRESSURE IN POUNDS PER SQ. IN.	FRACTIONS	DECIMALS	ON TOOL	PER SQ. IN.
1/8	930	0.0252	592	188000	483	0.0164	475	232000	954	0.0212	337	127000					1/64	0.01562	289	146206
	931	0.0320	854	213000	484	0.0286	552	154000	955	0.0328	526	128000					1/32	0.03125	480	122899
	932	0.0452	723	128000	485	0.0440	721	141000	956	0.0460	772	134000					3/64	0.04687	651	111092
	933	0.0608	970	127000	486	0.0635	905	114000	957	0.0628	805	102000	1153	0.0640	1430	178000	1/16	0.06250	808	103383
	934	0.0916	1167	102000	487	0.0900	1115	99000	958	0.0908	1019	90000	1154	0.0928	1820	157000	5/64	0.09375	1168	93419
	935	0.1288	1266	79000	488	0.1403	1490	88000	959	0.1292	1315	81000	1155	0.1300	2325	135000	1/8	0.12500	1358	86930
									960	0.1840	1740	77000	1156	0.1850	3166	140000	3/16	0.18750	1764	78604
3/16	936	0.0212	576	145000	489	0.0168	581	184000	961	0.0212	525	132000					1/64	0.01562	417	142379
	937	0.0324	914	150000	490	0.0292	581	106000	962	0.0320	881	147000					1/32	0.03125	701	119683
	938	0.0460	1016	118000	491	0.0446	888	106000	963	0.0460	1000	114000	1157	0.0460	1220	141000	3/64	0.04687	951	108184
	939	0.0612	983	86000	492	0.0625	1195	102000	964	0.0628	1355	115000	1158	0.0648	1775	145000	1/16	0.06259	1180	100677
	940	0.0920	1202	69000	493	0.0900	1533	90000	965	0.0908	1643	96000	1159	0.0928	2360	135000	5/64	0.09375	1599	90974
	941	0.1292	1642	67000	494	0.1234	2100	93000	966	0.1292	2115	90000	1160	0.1300	2860	117000	1/8	0.12500	1984	84648
									967	0.1848	2618	75000	1161	0.1815	4070	119000	3/16	0.18750	2690	76503
9/32	942	0.0212	793	132000	512	0.0174	684	139000	968	0.0212	751	126000					1/64	0.01562	609	138511
	943	0.0320	1008	112000	511	0.0294	735	88000	969	0.0320	1135	126000	1162	0.0324	1545	169000	1/32	0.03125	1024	116474
	944	0.0460	1405	108000	510	0.0452	1163	91000	970	0.0460	1467	113000	1163	0.0460	1925	148000	3/64	0.04687	1364	105266
	945	0.0612	1570	93000	509	0.0625	1317	74000	971	0.0628	1785	92000	1164	0.0608	2478	144000	1/16	0.06250	1722	97942
	946	0.0900	1883	74000	508	0.0909	1949	76000	972	0.0912	2205	86000	1165	0.0908	3440	134000	5/64	0.09375	2334	88502
	947	0.1280	2628	72000	507	0.1282	2600	72000	973	0.1292	2670	82000	1166	0.1250	4485	127000	1/8	0.12500	2893	82294
									974	0.1828	3810	74000	1167	0.1800	5570	110000	3/16	0.18750	3933	74474
27/64	948	0.0220	1088	117000	501	0.0162	998	146000	975	0.0212	1052	114000	1168	0.0204	986	114000	1/64	0.01562	889	134817
	949	0.0324	2012	149000	502	0.0264	1260	113000	976	0.0320	1757	120000	1169	0.0320	2250	166000	1/32	0.03125	1495	113368
	950	0.0460	2068	107000	503	0.0452	1770	92000	977	0.0460	2088	107000	1170	0.0460	2880	148000	3/64	0.04687	2026	102439
	951	0.0620	2321	88000	504	0.0625	2345	88000	978	0.0628	2568	91000	1171	0.0608	3740	145000	1/16	0.06250	2514	95330
	952	0.0900	2940	77000	505	0.0926	3200	82000	979	0.0912	3373	87000	1172	0.0912	4960	128000	5/64	0.09375	3453	86143
	953	0.1327	4240	73000	506	0.1250	3830	72000	980	0.1292	4108	75000	1173	0.1288	6850	126000	1/8	0.12500	4227	80158
81/128					500	0.0156	1556	157000	981	0.0212	1984	142000	1174	0.0200	2688	212000	1/64	0.01562	1297	131222
					499	0.0280	2090	117000	982	0.0320	2245	111000	1175	0.0312	3490	177000	1/32	0.03125	2183	110344
					498	0.0446	3020	107000	983	0.0452	3164	110000	1176	0.0460	4865	167000	3/64	0.04687	2958	99707
					496	0.0588	4040	109000	984	0.0640	4022	99000	1177	0.0608	5660	145000	1/16	0.06250	3670	92788
					497	0.0901	5095	89000	985	0.0900	4744	83000	1178	0.0900	6960	122000	5/64	0.09375	4974	83845
					495	0.1212	6240	81000									1/8	0.12500	6172	78025
243/256									986	0.0212	2482	123000					1/64	0.01562	1894	127722
									987	0.0320	3260	107000					1/32	0.03125	3189	107437
									988	0.0452	4140	96000					3/64	0.04687	4437	97052
									989	0.0612	5370	92000					1/16	0.06250	5358	90313

C. The same fact mathematically expressed is that in cutting the same piece of cast iron, the pressure of chip on the tool per square inch sectional area of chip grows greater as the thickness of the chip grows less in proportion to (thickness of the feed)$^{\frac{1}{2}}$ or $F^{\frac{1}{2}}$.

The pressure of chip per square inch of section also grows greater as the depth of the cut grows less in proportion to (depth cut)$^{\frac{1}{16}}$ or $D^{\frac{1}{16}}$.

D. The effect upon the pressure of the chip on the tool of a change in the thickness of the feed and the depth of the cut is the same for hard and soft cast iron, and is represented by the same general formula, with a change merely of the constant.

E. In taking cuts having the same depth and the same feed, the pressure of the chip on the tool becomes slightly greater, the larger the cutting tool that is used. This increase in the pressure follows from the fact that the larger the curve of the cutting edge of the tool, the thinner the shaving becomes.

Objects of Experiments on Pressure.

The principal object in making the experiments described in detail below was to determine, broadly speaking, the maxi-

mum pressures upon the tool per square inch of sectional area of the chip, both in cutting soft and hard cast iron, when our standard shop tools of different sizes were used, this information being needed in designing machine tools; for this purpose the highest pressure of 99 tons (2,000 pounds) as indicated in Table I., should be sufficient.

Our secondary object, and one of almost equal importance, was that of obtaining the pressure on tool per square inch of sectional area of the chip being cut, corresponding to various changes in the depth of cut and in the thickness of the feed. This information is needed in determining by means of our slide rules the exact sized cut which each machine tool is capable of taking under its possible combinations of pulling power, speed and changes in the thickness of feed.

In Table I. will be seen a summary of the actual pressures obtained under various conditions in these experiments, and in adjoining columns the pressures are reduced to pounds per square inch of sectional area of chip. The same data for ½, ¾ and 1¼-inch tools are reported in the diagram, Fig. 45.

On the left-hand side of this diagram is recorded the regularly increasing pressures per square inch of sectional area of the chip upon the tool; while on the bottom line are recorded the regular increases in the thickness of the feed.

In a series of heavy lines on the diagram are drawn curves corresponding to the following formula, which expresses the general relation existing between the depth of cut and the feed, and the pressure on the tool for all of the grades of cast iron experimented upon:

$$P = C\, D^{\frac{1}{2}}\, F^{\frac{3}{4}}$$

in which

P = the pressure on the tool;

D = depth of cut in inches;

F = feed in inches;

C = a constant depending upon the softness or hardness of the cast iron, and which varies between the limits of 45,000 for soft and 69,000 for hard cast iron, as experimented on by us.

illustrating the relative pressures of a thin feed on the one hand and a coarse feed on the other.

Depth of cut, $\frac{3}{16}$ inch, × feed, 0.0156 inch = Total pressure per sq. in. sectional area of chip, 295,000 lbs.

Depth of cut, $\frac{3}{16}$ inch, × feed, 0.125 inch = Total pressure per sq. in. sectional area of chip, 257,000 lbs.

C. The same fact mathematically expressed is that in cutting the same piece of steel, the pressure of the chip on the tool per square inch of sectional area of the chip grows greater as the thickness of the chip grows less in proportion to (thickness of the feed)$^{\frac{1}{16}}$ or $F^{\frac{1}{16}}$.

The pressure of the chip is in direct proportion to the depth of the cut.

D. Within the limits of cutting speed in common use, the pressure of the chip upon the tool is the same whether fast or slow cutting speeds are used.

E. The pressure of the chip upon the tool depends but little upon the hardness or softness of the steel being cut, but increases as the quality of the steel grows finer. In other words, high grades of steel, whether soft or hard, give greater pressures on the tool than are given by inferior qualities of steel.

F. The pressure of the chip on the tool per square inch of sectional area of the chip depends both upon the tensile strength of the steel and its percentage of stretch, and increases both as the tensile strength and stretch increase; although a higher tensile strength has more effect than a large percentage of stretch in increasing the pressure.

TABLE II. PRESSURES OF THE CHIP ON THE TOOL IN CUTTING STEEL WITH STANDARD TOOLS, CLEARANCE ANGLE 6 DEGREES, BACK SLOPE 8 DEGREES, SIDE SLOPE 14 DEGREES.

	½" TOOL — CUTTING SPEED ABOUT 60' PER MINUTE				¾" TOOL — CUTTING SPEED ABOUT 30' PER MINUTE				¾" TOOL — CUTTING SPEED ABOUT 60' PER MINUTE				1¼" TOOL — CUTTING SPEED ABOUT 30' PER MINUTE				PRESSURE IN POUNDS, FIGURED BY FORMULA—230,000 $DF^{\frac{3}{4}}$. COMPARE THESE PRESSURES WITH THE EXPERIMENTAL PRESSURES IN THE OTHER FOUR COLUMNS OF THIS TABLE			
DEPTH OF CUT IN INCHES	EXPERIMENT NUMBER	FEED IN INCHES	PRESSURE IN POUNDS: ON TOOL	PRESSURE IN POUNDS: PER SQ. IN.	EXPERIMENT NUMBER	FEED IN INCHES	PRESSURE IN POUNDS: ON TOOL	PRESSURE IN POUNDS: PER SQ. IN.	EXPERIMENT NUMBER	FEED IN INCHES	PRESSURE IN POUNDS: ON TOOL	PRESSURE IN POUNDS: PER SQ. IN.	EXPERIMENT NUMBER	FEED IN INCHES	PRESSURE IN POUNDS: ON TOOL	PRESSURE IN POUNDS: PER SQ. IN.	FEED IN: FRACTIONS	FEED IN: DECIMALS	PRESSURE IN POUNDS: ON TOOL	PRESSURE IN POUNDS: PER SQ. IN
	565	0.0154	586	304000					435	0.0144	605	336000	541	0.0186	709	306000	1/64	0.01562	593	303550
	566	0.0305	1040	273000					434	0.0281	907	258000	542	0.0296	1124	304000	1/32	0.03125	1132	289842
1/8	567	0.0422	1730	328000	535	0.0460	1537	267000	433	0.0428	1286	240000	543	0.0448	1615	288000	3/64	0.04687	1653	282054
	568	0.0625	2120	271000					432	0.0606	1928	254000	544	0.0608	1930	253000	1/16	0.06250	2162	276754
	569	0.0909	2850	250000	534	0.0909	3230	284000	431	0.0888	3175	286000	545	0.0930	3230	278000	5/64	0.09375	3156	269314
					534½	0.1282	4138	256000	430	0.1275	3855	242000	546	0.1250	4510	288000	1/8	0.12500	4129	264256
	570	0.0166	993	319000					415	0.0115	736	341000	552	0.0156	865	295000	1/64	0.01562	889	303550
	571	0.0275	1400	271000	523	0.0314	1542	262000	414	0.0280	1345	256000	551	0.0300	1496	266000	1/32	0.03125	1698	289842
3/16	572	0.0420	2690	341000					413	0.0414	2238	288000	550	0.0440	1986	241000	3/64	0.04687	2479	282054
	573	0.0625	3100	265000	520	0.0625	2721	232000	412	0.0625	3020	258000	549	0.0632	2760	237000	1/16	0.06250	3243	276754
					521	0.0885	4150	250000	416	0.0882	4884	295000	548	0.0909	4600	270000	5/64	0.09375	4734	269314
					522	0.0125	6620	282000	538	0.1250	5160	220000	547	0.1250	6000	257000	1/8	0.12500	6194	264256
					539		5700	243000												
	574	0.0148	1300	342000					429	0.0140	1184	301000	553	0.0148	1230	296000	1/64	0.01562	1334	303550
9/32	575	0.0275	2100	272000	530	0.0310	2230	255000	428	0.0287	2405	298000	554	0.0286	2135	265000	1/32	0.03125	2547	289842
					531	0.0452	3520	277000	427	0.0423	3320	278000	555	0.0403	2790	246000	3/64	0.04687	3718	282054
					532	0.0606	4430	239000	426	0.0620	4680	268000	556	0.0645	4630	255000	1/16	0.06250	4865	276754
					533	0.0909	7050	275000	425	0.0909	6708	262000	557	0.0909	6680	248000	5/64	0.09375	7101	269314
	577	0.0148	2130	341000					424	0.0150	1932	305000	558	0.0174	2090	285000	1/64	0.01562	2001	303550
27/64					529	0.0300	3680	290000	423	0.0298	3665	291000	559	0.0285	3360	279000	1/32	0.03125	3821	289842
					527	0.0448	5460	238000	422	0.0427	4930	273000	560	0.0405	4640	271000	3/64	0.04687	5578	282054
					528	0.0625	6920	262000	421	0.0552	6200	266000	561	0.0606	5760	225000	1/16	0.06250	7297	276754
													576		6730	263000				
					525	0.0182	4270	371000					562	0.0154	2980	305000	1/64	0.01562	3001	303550
81/128					524	0.0306	6140	317000					563	0.0282	5760	327000	1/32	0.03125	5732	289842
					526	0.0415	7815	297000	420	0.0424	7776	289000	564	0.0400	7700	304000	3/64	0.04687	8367	283054

Pressure of the Chip on the Tool in Cutting Steel.

The following are the general conclusions arrived at on this subject:

A. The total pressure of the chip on the tool in cutting steel of the different qualities experimented upon by us varies between the low limit of 92 tons (2,000 pounds) per square inch of sectional area of the chip, and the high limit of 168 tons per square inch sectional area of the chip.

B. In cutting the same piece of steel, the pressure of the chip on the tool per square inch of sectional area of the chip grows very slightly greater as the chip becomes thinner, and is practically the same whether the cut is deep or shallow; see Table II., from which are taken the following typical cases

Power Required to Feed the Tool.

By far the most important conclusion arrived at by us in the field of "Pressure of the Chip on the Tool" is that the gearing designed in lathes, boring mills, etc., for feeding the tool should be sufficiently strong to deliver at the nose of the tool *a feeding pressure equal to the entire driving pressure of the chip upon the lip surface of the tool.* This fact was developed by us in an experiment made in the year 1883 in the works of the Midvale Steel Company, and had such an important bearing upon the cost of turning out the product in the machine shop of those works that the results of this one simple investigation more than paid for all the experiments in the entire field of cutting metals undertaken in the Midvale Steel works.

All of the lathes, boring mills, etc., purchased by this company from that time forward were fitted with feed gearing designed with power equal to the driving power of the machine, and in this way the many stoppages and delays so common in the average machine shop, due to broken feed gearing, were avoided. What is of even much greater importance, a lack of strength in the feed gearing, never was accepted as an excuse on the part of any machinist for not taking the maximum cut on his machine. But in this respect this company stood alone for at least fifteen years.

BENDING STRESSES IN WIRE ROPE.

JAMES F. HOWE.*

James F. Howe.†

The study of different engineering problems brings out the proposition of two kinds of stresses, one seen and the other unseen. Those stresses which are caused by direct thrust or pull are easily seen and provided for, but the unknown forces, or the ones which fail to make an impression on our senses, are more difficult to grasp. Engineers have provided for such forces on some kinds of work by using a larger factor of safety. This method at best, however, only approximates, and should never be used except as a last resort, after all possible means for the determination of the stresses have been exhausted.

Wire rope, on account of its numerous applications to various engineering problems, such as derricks, traveling cranes, elevators, ore- and coal-handling machinery, etc., is becoming a vital adjunct to the solution of the problem of the economical handling of many different materials. The draftsman or designer of any apparatus requiring the use of wire rope has to decide upon the size of sheaves and drums which he will employ, and in a great many cases has only a vague idea of what size these should be made. To be sure, the catalogues of wire rope manufacturers give in a general way the smallest diameter of sheave or drum that should be used for any given size of rope, but it was never intended that sizes of sheave given as a minimum should be the only size to employ. Nevertheless, judged by this standard, a good many pieces of apparatus, of excellent design in other respects, show an almost total disregard for such recommendations, and the sheaves and drums used are of extremely small diameter. This is caused by a desire to make a compact apparatus, and to bring the first cost as low as possible, both of which are desirable features from a business standpoint. The purchaser of such an apparatus, however, is also interested in the cost of maintenance as well as in the first cost. He finds after a short

TABLE I. TOTAL AREA IN SQUARE INCHES OF WIRES OF DIFFERENT ROPES.

Diameter of Rope.	6 x 7 Construction.	6 x 19 Construction.	6 x 37 Construction.	8 x 19 Construction
2 3/4	.....	2.6892	2.6704	.....
2 1/2	.....	2.2224	2.2068	.....
2 1/4	.....	1.8000	1.7876	.....
2	.....	1.4216	1.4124	.....
1 3/4	.....	1.0888	1.0812	.....
1 5/8	.....	0.9390	0.9324	.....
1 1/2	0.8334	0.7997	0.7929	0.6714
1 3/8	0.7007	0.6723	0.6676	0.5643
1 1/4	0.5791	0.5556	0.5517	0.4664
1 1/8	0.4691	0.4500	0.4469	0.3778
1	0.3706	0.3554	0.3531	0.2985
7/8	0 2840	0.2722	0.2703	0.2285
3/4	0.2134	0.1999	0.1982	0.1678
5/8	0.1448	0.1389	0.1379	0.1166
9/16	0.1173	0.1125	0.1117	0.0945
1/2	0.0926	0.0889	0.0883	0.0746
7/16	0.0710	0.0681	0.0676	0.0571
3/8	0.0534	0.0500	0.0495	0.0419
5/16	0.0362	0.0347	0.0345	0.0291
1/4	0.0231	0.0222	0.0221	0.0186

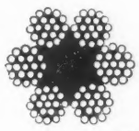
period that his ropes have all gone to pieces, and procures another rope only to get the same result. In the design of his machine too small sheaves were used, and he finds it necessary to replace, at considerable expense, the small sheaves by larger ones, or to continue to have a high cost of maintenance.

An example of this will perhaps make this point clear. A 1¼-inch crucible steel rope 6 x 19 runs over a 3-foot sheave and drum on a machine designed to lift 10 tons. According to the tables furnished by rope manufacturers, this rope has a strength of 50 tons, which would give a factor of safety of 5. We will assume that the factor 5 is as small as it is advisable to use for this particular service. What we actually have, however, is this:

Stress on rope due to load to be lifted..... = 10.00 tons
Stress on rope due to bending over 3-foot sheave. = 7.25 tons

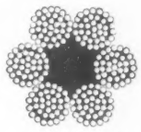
Total stress ..... = 17.25 tons.

This gives a factor of safety of less than 3, which is altogether too small, showing how necessary it is to take into account the bending stress due to winding around a pulley or drum. It would be necessary to use in this case either a



Machinery, N.Y.

TABLE II. STRENGTH OF 6x19 AND 6x37 ROPES.



Machinery, N.Y.

Diameter in Inches.	Approximate Circumference in Inches.	Weight per Foot in Pounds.	Approximate Breaking Stress in Tons of 2000 Pounds. Iron.	Approximate Breaking Stress in Tons of 2000 Pounds. Crucible Steel.	Approximate Breaking Stress in Tons of 2000 Pounds. Plow Steel.
2 3/4	8 5/8	11.95	114	228	305
2 1/2	7 7/8	9.85	95	190	254
2 1/4	7 1/8	8.00	78	156	208
2	6 1/4	6.30	62	124	165
1 3/4	5 1/2	4 85	48	96	128
1 5/8	5	4.15	42	84	111
1 1/2	4 3/4	3.55	36	72	96
1 3/8	4 1/4	3.00	31	62	82
1 1/4	4	2.45	25	50	67
1 1/8	3 1/2	2.00	21	42	56
1	3	1.58	17	34	44
7/8	2 3/4	1.20	13	26	34
3/4	2 1/4	0.89	9.7	19.4	25
5/8	2	0.62	6.8	13.6	18
9/16	1 3/4	0.50	5.5	11.0	14.5
1/2	1 1/2	0.39	4.4	8.8	11.4
7/16	1 1/4	0.30	3 4	6.8	8.85
3/8	1 1/8	0.22	2.5	5.0	6.55
5/16	1	0.15	1.7	3.4	4.50
1/4	3/4	0.10	1.2	2.4	3.00

larger rope and larger sheaves and drums, or a stronger rope and sheaves and drums enough larger to reduce the bending stress to a smaller amount. A 1¼-inch plow steel rope, 6 x 19, has a strength of 67 tons, and with a factor of safety of 5 gives a working stress of 13.4 tons. The problem could then be solved as follows:

Stress on rope due to load to be lifted..... = 10.00 tons
Stress on rope due to bending over 6-foot 6-inch sheave ..... = 3.36 tons

Total stress ..... = 13.36 tons.

Note that the sheave had to be increased to more than double its original size to reduce the stress sufficiently. The bending stresses given in the two cases outlined above are the actual stresses that any rope of the construction noted would have. The comparison above shows how vital it is that the bending stresses be carefully considered.

For the purpose of determining what the stress is, the writer has plotted curves for various kinds of commercial ropes of standard makers and various constructions. These curves, given in the Data Sheet, show graphically the effect of the different sizes of sheaves on different ropes, so that it is possible for anyone to look at the curves and tell at a glance exactly what bending stress is put on the rope. For example, take the curves for 6 x 19 ropes. There are two sets of curves for this kind of rope, one plotted to show the relation between the diameter of rope and the bending stress, and the other between the diameter of rope and the size of the sheave. With any two factors known, the third can easily

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be obtained. Suppose that we desire to use a 1-inch diameter, 6 x 19 rope, of a strength of 34 tons to hoist a load of 4 tons. What is the minimum size sheave that can be used with a factor of safety of 5?

34 tons divided by 5... = 6.8 tons total permissible stress
Direct load ..... = 4.0 tons

Difference ..... = 2.8 tons permissible bending stress.

Using the diagram for 6 x 19 rope, we find that the line representing 2.8 tons stress intersects the line for 1-inch rope on the curve marked 4 feet. Consequently we will require a sheave 4 feet in diameter.

We can reverse the question. A 6 x 19 rope, 1 inch in diameter, is to be run over a 3-foot sheave; what load will it lift, assuming a factor of safety of 5 and a strength of rope given as 34 tons? Referring to the curves for 6 x 19 rope, we find by following the line for 1-inch rope until it intersects the line for a 3-foot sheave that the bending stress lies between the curves for 3 tons and 4 tons. By proportioning, we find that it is about 3.7 tons.

34 tons divided by 5... = 6.8 tons total permissible stress
Deducting ..... 3.7 tons bending stress

Difference ..... = 3.1 tons allowable working load.

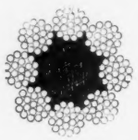
Calculations to Obtain Curves.

The method of calculating these curves is as follows:

Let S = stress per square inch,
E = Young's modulus of elasticity of steel = 29,000,000,
E_r = modulus of elasticity of the rope as a whole,
d = diameter of wire of rope in inches,
d_r = diameter of rope in inches,
D = diameter of sheave or drum in inches.

E_r is a function of E, that is, it is dependent upon its value. E_r is less than E on account of the structure of a rope, and

TABLE III. STRENGTH OF 8 x 19 ROPES.



Machinery, N.Y.

Diameter in Inches.	Approximate Circumference in Inches.	Weight per Foot in Pounds.	Approximate Breaking Stress in Tons of 2000 Pounds. Crucible Steel.	Approximate Breaking Stress in Tons of 2000 Pounds. Plow Steel.
1 1/2	4 3/4	3.48	65	86
1 3/8	4 1/4	2.51	56	74
1 1/4	4	2.13	45	60
1 1/8	3 1/2	1.82	38	50
1	3	1.32	27	35
7/8	2 3/4	1.05	21	27
3/4	2 1/4	0.89	16.5	21
5/8	2	0.53	11.6	15
9/16	1 3/4	0.43	9.4	12.3
1/2	1 1/2	0.31	6.6	8.55
7/16	1 1/4	0.27	6.1	7.95
3/8	1 1/8	0.18	3.3	4.25
5/16	1	0.12	2.2	2.92
1/4	3/4	0.066	1.6	1.95

varies with the flexibility of same. A low modulus is indicative of a flexible rope and *vice versa*. In considering this problem, the writer takes into account the modulus of elasticity E_r of the rope as a whole. This conception is different from the ordinary conception of the modulus of elasticity, but is perfectly feasible, as the modulus of elasticity is, strictly speaking, the ratio between the force applied to any material per square inch and the amount of elongation expressed as a fraction of the original length.

The stress produced in a round bar of the diameter d_1, when bent around a sheave of diameter D, is given by the well-known formula:

$$S = E\frac{d_1}{D}. \qquad (1)$$

If for d_1 we substitute d, the diameter of the wire in rope, and for E the modulus of elasticity of the rope E_r, we have:

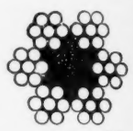
$$S = E_r\frac{d}{D}. \qquad (2)$$

From this formula we can get the required stress per square inch, if we know E_r and d. The following values of d and E_r have been calculated by the writer from various data:

For 6 x 7 rope, diameter of single wire = 0.1059 d_r
" 6 x 19 " " " " = 0.0629 d_r
" 6 x 37 " " " " = 0.0450 d_r
" 8 x 19 " " " " = 0.0499 d_r

Allowance has been made in these values for the angle of

TABLE IV. STRENGTH OF 6 x 7 ROPES.



Machinery, N.Y.

Diameter in Inches.	Approximate Circumference in Inches.	Weight per Foot in Pounds.	Approximate Breaking Stress in Tons of 2000 Pounds. Iron.	Approximate Breaking Stress in Tons of 2000 Pounds. Crucible Steel.	Approximate Breaking Stress in Tons of 2000 Pounds. Plow Steel.
1 1/2	4 3/4	3.55	34	68	91
1 3/8	4 1/4	3.00	29	58	78
1 1/4	4	2.45	24	48	64
1 1/8	3 1/2	2.00	20	40	53
1	3	1.58	16	32	42
7/8	2 3/4	1.20	12	24	32
3/4	2 1/4	0.89	9.3	18.6	24
11/16	2 1/8	0.75	7.9	15.8	21
5/8	2	0.62	6.6	13.2	17
9/16	1 3/4	0.50	5.3	10.6	14
1/2	1 1/2	0.39	4.2	8.4	11
7/16	1 1/4	0.30	3.3	6.6	8.55
3/8	1 1/8	0 22	2.4	4.8	6.35
5/16	1	0 15	1.7	3.4	4.35
9/32	7/8	0.125	1.4	2.8	3.65

twist of the strands and wires, which decreases the size of the wire somewhat in any given rope.

The values of E_r which the writer has obtained by theoretical calculation are:

For 6 x 7 rope, E_r = 13,700,000
" 6 x 19 " E_r = 12,000,000
" 6 x 37 " E_r = 11,300,000
" 8 x 19 " E_r = 11,000,000

These values of E_r have been checked from several sources and represent average commercial ropes in use to-day. Taking an actual case to show how to get the stress, we may assume that we have a case of 1½-inch diameter, 6 x 7 rope, on a 10-foot sheave. What is the stress? Using formula (2) we have:

$$S = \frac{13{,}700{,}000 \times 1\frac{1}{2} \times 0.1059}{12 \times 10}$$

= 18,100 pounds per square inch approx.

Area of a 1½-inch, 6 x 7 rope = 0.8334 square inch (see Table I.).

Hence, stress in rope = 0.8334 x 18,100
= 15,080 pounds = 7.54 tons bending stress.

Values for the other sizes of sheaves and drums were obtained in a similar manner for sufficient points to plot the curves given. It will be noted that these curves are of the form of a parabola, and the stresses of any two sizes of rope are to one another as the cube of the diameter, that is, on a given size sheave a rope 1 inch in diameter has eight times the stress of a ½-inch rope over the same diameter pulley.

Tables II., III. and IV. give the strength of the various kinds of ropes which are adopted as standards in the United States.

* * *

Disappearing paper is now quite extensively (?) used in letter writing. It is prepared by being steeped in sulphuric acid, after which it is dried and glazed, the acid being neutralized by ammonia vapor. After a certain number of days or weeks the paper falls to pieces.—*Mining Reporter.*

CUT OUT ON THIS LINE.

CUT OUT ON THIS LINE.

PUNCH PUNCH PUNCH PUNCH PUNCH PUNCH

These operation sheets, covering every class of shop work, are a feature of all Editions of MACHINERY, and appear every month. They may be cut along the top and margin lines for filing and binding. Suitable binders of sufficient capacity to hold four years' issues will be supplied by THE INDUSTRIAL PRESS, 49-55 Lafayette Street, New York, for 25 cents each, including postage.

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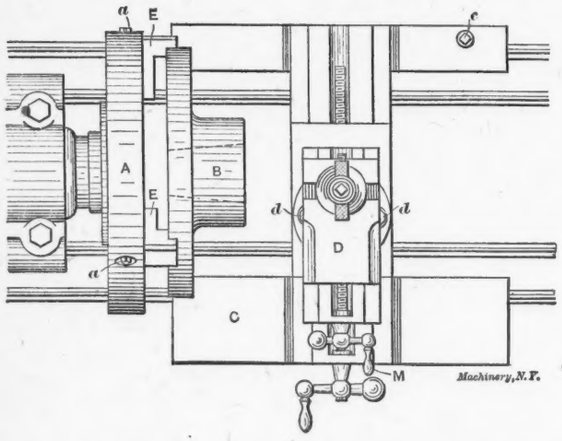
SHOP OPERATION SHEET NO. 4.

Oscar E. Perrigo. MACHINERY, June, 1907.



To Chuck a Cored Flanged Casting, for Boring and Reaming a Taper Hole.

1. Provide a three-jawed chuck for this job, the screws of which are connected by the usual ring bevel gear within the casing, this form being what is commonly known as a self-centering or "universal" chuck.

2. Put this chuck *A* on the lathe spindle and screw it up tight against the collar. See that there is no dirt between the collar and chuck face-plate to cause the chuck to run out of true.

3. The jaws *E* must be turned around so that the steps face inward, as shown in the cut, if they be found in the reversed position required for internal chucking.

4. Put the casting *B* in the jaws of the chuck, with the large diameter of the cored hole facing the right, and be sure that the piece sits back fairly against the face of the jaws.

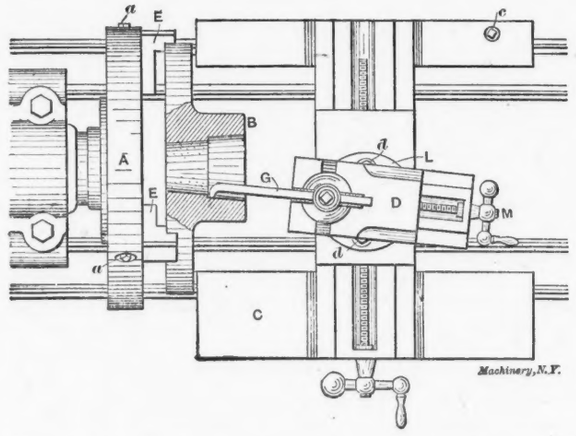
5. Screw up the chuck jaws by applying the chuck wrench to one of the jaw screws *a*, and successively to the others.

6. Start up the lathe slowly, and by applying a piece of chalk, first to the face and then to the outside of the casting, note whether or not it runs true. If not, there is likely to be a slight unevenness on the casting where it rests against one of the jaws. Loosen the jaws, turn the casting slightly, screw up the jaws, and test as before. Continue this until the casting runs nearly or quite true.

Note.—In some cases it may be required to face the hub of the casting *B* before it is bored. If this is to be done the lathe carriage *C* should be brought up somewhat closer than the position shown. Put a right-hand side tool in the tool-post of the compound rest *D*, set at an angle of about 20 degrees to the face of the hub of the casting, clamp in place, and take a roughing and finishing cut on the face of the hub. This gives a somewhat better condition to start the boring cut, whether especially required or not.

SHOP OPERATION SHEET NO. 5.

Oscar E. Perrigo. MACHINERY, June, 1907.



To Bore Out a Cored Taper Hole for Reaming to a Taper of 6 Degrees with the Center Line, 4 Inches Diameter at Large End.

1. Loosen the clamp nuts *d*, and swing the compound rest around to the angle of 6 degrees to the center line of the lathe, reading the graduations at *L*, and clamp in position.

2. Screw the compound rest to the right nearly as far as it will go, so as to have its full travel available for boring. Move the carriage *C* to such a position on the lathe bed that the front end of the compound rest slide will be a little farther from the casting to be bored than the entire distance through it, and clamp the carriage in position by the screw *c*.

3. Set a stiff inside boring tool *G* as shown, and at a little less angle than that of the compound rest, and with its point projecting a little more than the whole depth of the hole to be bored. The height of the cutting edge should be the center of the lathe. Use as large and stiff a tool as possible.

4. Speed the lathe at about 30 revolutions per minute with carbon steel tool, and at 60 revolutions per minute with high-speed steel tool, on cast iron.

5. Proceed to take a roughing cut, using the handle *M* on the compound rest feed screw for a hand feed. Feed evenly, turning the handle *M* an equal amount for each revolution of the work.

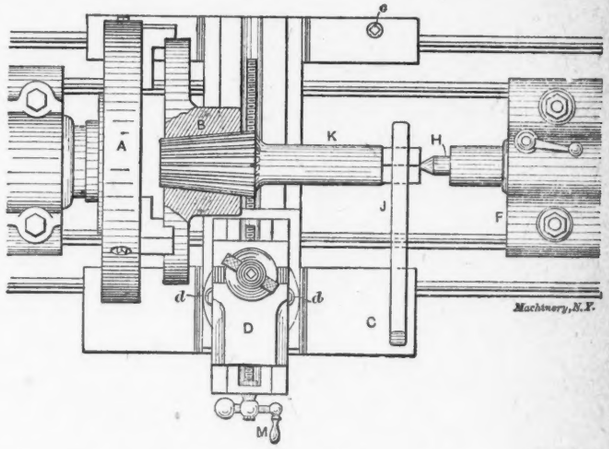
6. To ascertain if the proper angle is obtained, try the reamer into the taper hole. If not correct, adjust the compound rest as found necessary.

7. Make a second roughing cut, enlarging the hole to nearly the diameter for reaming. This cut is usually necessary, because a cored hole is seldom exactly concentric with the outside of the casting. Try the reamer again to see that the proper angle has been obtained.

8. See that the boring tool is sharp and of proper form, and proceed to make a finishing cut, enlarging the hole to about 0.01 inch smaller than the given dimension at large end.

SHOP OPERATION SHEET NO. 6.

Oscar E. Perrigo. MACHINERY, June, 1907.



To Ream a Taper Hole, 4 Inches Diameter at the Large End, in a Bored Casting Held in a Chuck.

1. The casting is supposed to have been bored in a previous operation and to have been truly chucked. Remove the tool from the tool-post, and run the carriage to the position shown.

2. Select a reamer *K* of the proper diameter and taper, and place it in the taper hole, as shown. Bring forward the tail-stock *F* and clamp it in proper position, with the tail-spindle center *H* entering the reamed hole in the rear end of the taper reamer to support it.

3. Upon the squared end of the taper reamer *K* place the holder or wrench *J* to prevent it from rotating.

4. Start up the lathe slowly and permit the cutting edges of the reamer to cut, carefully pressing it into the hole by the use of the tail-stock hand-wheel, operated with the right hand, while the left hand steadies the holder *J*. Raise the holder from its contact with the lathe carriage and exert what resistance may be necessary to prevent it from turning, and at the same time "feel" whether it is cutting properly or not.

5. As soon as the cutting edges have come to a good cutting contact, remove the reamer, stop the lathe, and caliper the large end of the hole, remembering that a taper reamer is liable to enlarge the hole very rapidly.

6. Repeat this operation of reaming a little and then measuring until the proper diameter is obtained. Mark reamer when proper depth has been reached if more holes of same size are to be reamed.

Note.—When many like pieces are to be bored and reamed, it is customary to provide a hardened and ground taper plug as a gage, a mark having been made upon it to indicate the extent to which it must enter the hole to determine the standard diameter. However, when only one or a few pieces are to be bored and reamed, it is customary to give the dimension of the large end of the hole on the drawing.

LETTERS UPON PRACTICAL SUBJECTS.

GEAR SHAPING ATTACHMENT FOR THE SLOTTER.

The accompanying line cut and halftone show an attachment for the slotter for cutting the teeth in quadrants. Referring first to the line cut, Fig. 2, *A* is a forging made as shown in the detailed view, having a tongue to fit into the slotter table. At *C* is shown another forging, bored to fit the projecting pin of *A*. Into this forging *C* the arms *E* are inserted, having a ball seat on each side, and nuts made to cor-

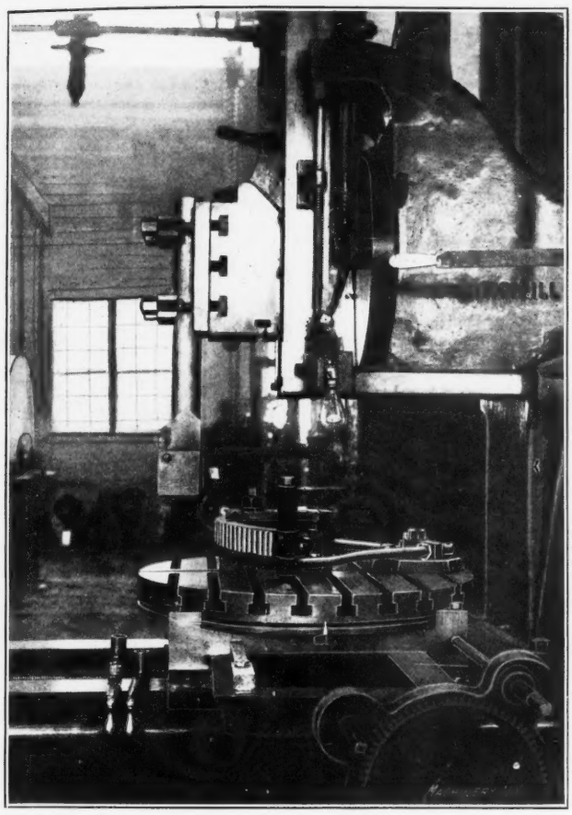


Fig. 1. Gear Shaping Attachment for the Slotter.

respond. While this refinement of the construction may not be a necessity, it still is an improvement. For various sizes of quadrants it is necessary to have arms of different lengths.

The quadrants are first machined on the sides and faces, and after that two holes are drilled and studs *G* made, having a nice fit in these holes, the studs being as long as required to take one or more gear sectors at a time. The first two teeth should be laid off on the quadrant if there is no templet having the teeth already cut. It is advisable, however, to make a templet out of a piece of steel about ⅛ inch thick. When making the templet, the sheet steel may be bolted to the quadrant, the teeth of which are to be cut. The teeth are then laid out to the proper shape and slotted at the same time as the teeth are cut in the quadrant. When this templet is once made, it will last for years, and it will save the necessity of laying out any teeth at all on the quadrant to be cut.

However, if we assume that no templet is at hand, we lay out the first two teeth, and after adjusting the piece by oscillating the quadrant back and forth and noting that the tool point is in correct position, the quadrant is clamped down to the table with two clamps. The first tooth is then cut.

While the first tooth is cut the carriage of the machine is brought up tightly against a stop set on the bed. This stop is shown on the left-hand way of the machine in the halftone. As soon as the first tooth is cut, the tool is left in the space having been cut. The clamps holding the device to the table of the machine are loosened sufficiently to allow the quadrant to be moved on the pivot, and the carriage is then moved away from the stop a distance equal to the pitch of the teeth to be cut. As the tool is left in place in the quadrant, the movement of the carriage evidently turns the device around its pivot, thus, in fact, indexing the quadrant for the next tooth to be cut. When the carriage has been moved what is supposed to be the correct amount, corresponding to the pitch, the clamps are again tightened, the tool is raised above the quadrant, and the carriage brought back against the stop. The tool now ought to be exactly over the second space laid out on the quadrant, and ready to cut the second tooth. By having the next tooth laid out, it is easy to see whether the carriage has been moved the correct distance. If it has, a small plug may be turned about 1½ inch long and with a diameter equal to the amount that it was necessary to move the carriage away from the stop in order to index for the next tooth. When this plug is made, it is stamped with the radius and the pitch of the quadrant, and can be used for all other quadrants of the same kind in the future. All the other teeth in the quadrant are cut by proceeding for each tooth in the same manner as outlined for the first two teeth. If it is found that the radius of the quadrant on which the teeth are to be cut is too large, so that the pivot block *A* cannot be bolted to the table of the machine, an extension pivot block can be made to extend sufficiently over the edge of the table,

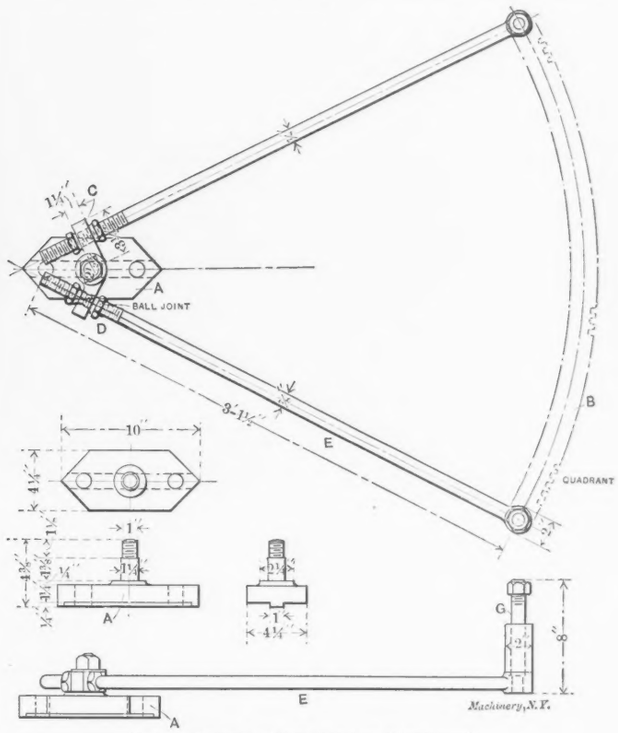


Fig. 2. Details of Gear Shaping Attachment.

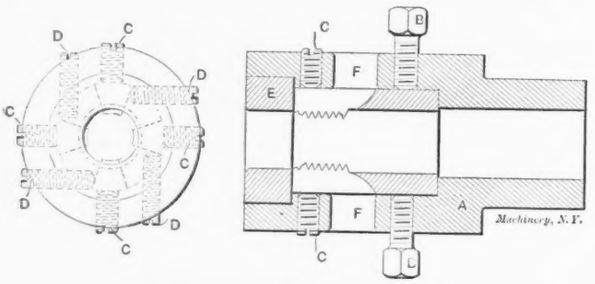
so that the part being machined can be placed on the table, which of course is necessary in order to obtain satisfactory support for the work. This method is much quicker than milling. By actual test I find that it saves 40 per cent of the time required in milling. M. H. W.

HOLDER FOR SPRING SCREW THREADING DIES.

From time to time some one comes forth and tells us in the mechanical papers a great many things about screw-threading dies. It is not my intention to expound that theory here, but I wish to describe a die holder by the use of which spring screw dies can be used to much better advantage than they sometimes are. Suppose that a screw is to be made on the screw machine, and that it is required that the thread must be exact in lead, so that it can be screwed into a tapped hole and fit properly all the way in, and that the thread shall be concentric with the body of the screw, so that when it is being screwed into place, the piece it is to hold will be located in its proper location. Some adjustable dies will cut this

thread fairly well, but solid dies do not, as a rule. The worst die to use is the spring screw die, whose slender jaws spring away from the cut and produce an incorrect pitch. I have seen screws cut in this manner that would not enter a tapped hole but three or four threads, but a thin gage would fit nicely all the way up. This weak point of the slender jaws can be made an advantageous feature if a proper holder is made, into which the die is placed, and necessary screws used to adjust and hold the prongs. Such a holder is shown in the cut. This method of holding the die gives to the spring screw die all the qualities of a solid die without losing any of the adjustable qualities of the spring die.

It will be seen from the cut that the die is held rigidly within a solid holder *A*, the shank of which fits the regular die



Holder for Spring Screw Threading Dies.

holder or chuck. The screws *B* hold the die in place. The screws *C* adjust the die in regard to the size independently of one another. These separate adjustments are convenient, for it is often necessary to adjust one jaw more than another. The screws *D* give a backing to the jaws and prevent them from springing away from the cut. A hardened bushing *E*, held in front of the die, guides the work when entering the die so that the thread will be concentric with the blank. The holes *F* permit the oil to enter the die and the chips to pass away from the cut.

When adjusting the die, use a master screw. Screw it into the die through the bushing and adjust the jaws until they barely touch the thread of the master screw. The die is then ready for use. The first screw made should be gaged, and readjustment should be made according to requirements. A little practice will enable the operator to adjust the die without any trouble. This holder will also be found to be convenient for holding the die when rehobbing it. Often one jaw needs more hobbing than another, and by means of the screws *C* this can be accomplished. The bushing *E* will be found to be an excellent guide for the hob.

The most satisfactory way of annealing dies to prevent them from cracking when they are hardened after rehobbing, is to pack them in a regular case-hardening box with charcoal, and put them in a furnace with a regular charge, and if possible permit the box to remain in the furnace to cool. If this, however, is not convenient, remove the box with the charge and set it aside in a warm place until the dies are cool enough to be taken out. Do not allow the air to strike the dies while they are hot. If these directions are properly followed, this method will tend to keep the dies from cracking, and they can be used over and over as long as the threads last. The die holder shown has been in use over twenty years, which is long enough to prove that it gives satisfaction.

W. B. M.

"R. S." ONCE MORE REFUTED.

In the April issue of MACHINERY "R. S." gives a suggestion for finding the radius of an arc when its length and the length of the chord are given. I would like to say thereto that his method is incapable of solution. Let C be the length of the given chord, x the height of the given arc, and R the required radius; "R. S." then says that he now has two unknown quantities, R and x, and by finding two equations involving these two quantities, the problem may be solved. The equations he gives are:

$$R^2 = \left(\frac{C}{2}\right)^2 + (R - x)^2 \qquad (1)$$

$$(2\,R - x)\,x = \left(\frac{C}{2}\right)^2 \qquad (2)$$

The first is derived from the geometric proposition that the square of the hypotenuse of a right angle triangle equals the sum of the squares of the other two sides, and the second is derived from the proposition that if two chords intersect within a circle, the products of their respective segments are equal. Although these equations are geometrically correct, they cannot be solved algebraically, as they are not independent equations, *i.e.*, they do not show different relations between R and x. This is more easily seen by reducing them to their simplest form:

$$R^2 = \left(\frac{C}{2}\right)^2 + (R - x)^2 \qquad (1)$$

$$R^2 = \frac{C^2}{4} + R^2 - 2\,R\,x + x^2$$

$$2\,R\,x - x^2 = \frac{C^2}{4};\quad 8\,R\,x - 4\,x^2 = C^2$$

$$(2\,R - x)\,x = \left(\frac{C}{2}\right)^2 \qquad (2)$$

$$2\,R\,x - x^2 = \left(\frac{C}{2}\right)^2 = \frac{C^2}{4}$$

$$8\,R\,x - 4\,x^2 = C^2$$

Both thus reduce themselves to $8\,R\,x - 4\,x^2 = C^2$, indicating that they are mutually dependent and cannot be solved by any method for simultaneous equations.

It is safe to state that there is no elementary proposition by which R can be found in terms of C and the length of the arc alone; in fact, "R. S." tries by his method to find it in terms of C alone, which is quite a ridiculous assumption to begin with.

F. WALSLEBEN.

Brooklyn, N. Y.

[It would seem that "R. S." is quite unfortunate in his alleged discoveries. The readers of MACHINERY have a way of "sitting on him" that would discourage a less indefatigable investigator.—EDITOR.]

STEAM REVERSING VALVE FOR HOISTING ENGINE.

The accompanying Figs., 1 to 4, show the design of valves used on a small hoisting engine with 8 x 8-inch cylinders. The design is very simple, but I do not know who the originator was. The engine is built by the Victorian Foundry Company, Ottawa, for the Department of Public Works, to designs furnished by the department.

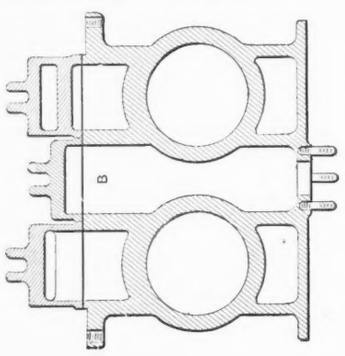


Fig. 1.

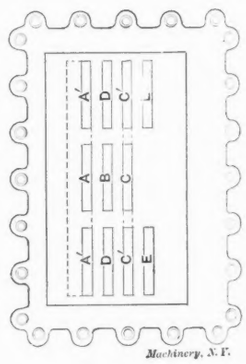


Fig. 2.

Fig. 1 shows section through exhaust passage *B* and steam ports; Fig. 2 shows valve seats and port openings; Fig. 3 shows section through distributing valve and ports *A* and *C*, also the exhaust passage; and Fig. 4 shows section through main valve and cylinder.

With the distributing valve in the position shown in Fig. 3, steam is admitted from the steam chest to port *A*, and through the passage shown into the main valve, Fig. 4; then through port *D* into cylinder. Exhaust is through port *E* into *C*, and then through passage to *C* and through the distributing valve down exhaust passage *B*. With the distributing valve moved

forward, the steam is admitted to C, C_1 and E and the cylinder exhaust takes place through D, A_1, A and B.

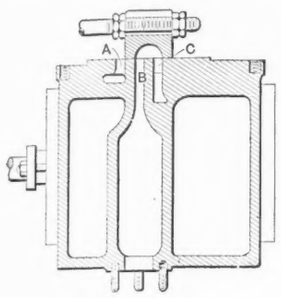


Fig. 3.

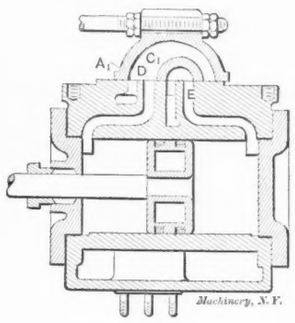


Fig. 4.

The simple action commends itself for small engines, as only one eccentric and connections are necessary for each cylinder.

J. S. IMLACH.

Ottawa, Can.

MILLING MACHINE BORING TOOL HOLDER.

The adjustable milling machine boring tool shown in the halftone, Fig. 1, and the line cut, Fig. 2, has proven very useful on jig and die work and can be used to advantage on any work of boring where accuracy is an important factor. A

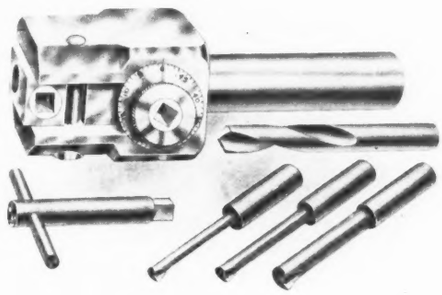


Fig. 1. Milling Machine Boring Tool Holder.

tool of the dimensions shown will bore holes from ¼ to 1 inch in diameter, and by making split bushings and using a small drill to start with, very much smaller holes can be bored. The tool-holder is made of tool steel throughout.

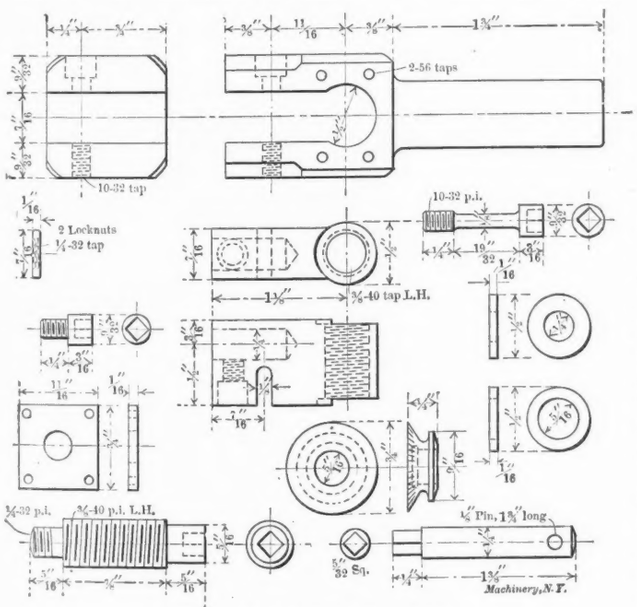


Fig. 2. Details of Boring Tool Holder.

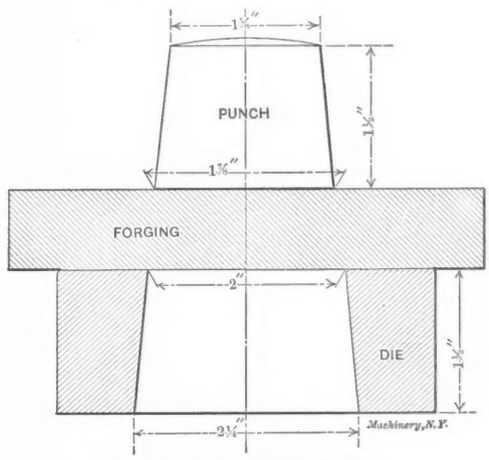
The 5/32-inch square socket key shown adjusts the feed screw as well as locks the carriage to the main part of the holder, and binds the tool in place. The feed screw is provided with two lock nuts and can be adjusted when worn. The dial, by means of which the amount that the feed screw is fed in is determined, is graduated into 50 divisions, each one representing 0.0005. The operator is therefore able to determine very small increases in the diameter of the hole to be bored. The screw itself is threaded left hand which permits right-hand movements of the dial.

J. N. EAGAN.

MAKING COLLARS WITH THE STEAM HAMMER.

Some years ago I was called upon to make a large number of collars of different sizes, and it was necessary that these collars should be made cheaply. The firm that I was with had been buying drop forgings for these collars, but I figured that it would be cheaper to make them in a different manner. Previous to my time in this particular shop they had used a great deal of round machine steel in various sizes from 2 to 4 inches in diameter, and they used to throw the ends of the bars out in the yard until there had accumulated a good-sized pile. This scrap I used for making collars.

I first made a set of dies of different sizes from 1½ to 4½ inches inside diameter, making the holes taper as shown in the cut. I then made a lot of short punches to correspond to these dies, but ⅛ inch smaller in diameter than the holes in the latter. None of the punches were longer than 2 inches, and some of them were not longer than 1¼ inch. These were also made taper, as shown in the cut. I then started to make the collars. After ascertaining the amount of material needed for a certain size of collar, I cut off three, four or five blanks from a piece of shafting at one heat. I then threw them back in the fire and took them one at a time to the steam hammer, hammering them down until they were about the right thickness, preferably a little thicker than the size



Punch and Die for Making Collars.

called for. I then rounded them up and flattened them again, placed the die in the steam hammer with the heated blank on it and the punch on top, as shown in the cut, and with one or two moderately hard blows of the hammer I drove the punch through very easily, and the collar was forged. For varying the size of the holes in the collars to be made, I made some taper pins of crucible tool steel to drive into the holes after they had been punched, so that I could make collars of any size and thickness. The plan was so successful, that after having used up the scrap steel, I used regular bar stock in making these collars. I also used the punchings from the larger collars for making smaller ones, so there was very little waste; in fact, I figured there was less than 15 per cent waste in all.

If the punch should happen to shear the die at any time, the blacksmith could work the die over in a few minutes by closing it up and then driving the punch in until the hole is again of the right size. It is not necessary to have sharp edges on the die and punch, but it is necessary to have the bottom and top of the punch as parallel as possible, so as to prevent the hammer from driving the punch to one side. Care should be taken that the punch is central on the blank before the hammer is applied, so that shearing the die will be avoided. I have punched over 700 collars on one die without any trouble.

Chicago, Ill. GEORGE T. COLES.

STRENGTH OF BOILER JOINTS.

It was with interest that I read the article in your February issue, Engineering Edition, respecting the above, and I would like to show (what is probably not known to all your readers) that the stress in the second row of rivets always amounts to more than in the first row. This is the case when a triple joint is used, having a narrow outer butt strap and a wide one inside, and when the pitch in the second row is half the pitch of the first, and all rivets have the same diameter.

I will now show how to calculate the stress of the shell plate at both rows of rivets, and for the sake of convenience, I take the joint shown in Fig. 1, same as in your February

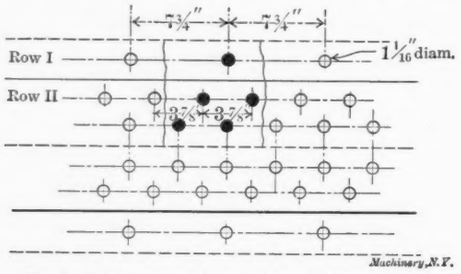


Fig. 1. Joint suggested in Article in February Issue.

issue, *i. e.*: shell, ⅝ inch; rivets, 1 1-16 inch = 1.06 inch, about; radius of shell, 29 inches; pitch, 7¾ inches; pressure, 200 pounds per square inch.

Row 1. Pull along one pitch = $7.75 \times 29 \times 200 = 45{,}000$ lbs.

Length of plate = 7¾ — 1 1-16 = 6.68 inches.

$$\text{Tearing of plate} = \frac{45{,}000}{6.68 \times 0.625} = 10{,}780 \text{ lbs. per sq. in.}$$

$$\text{Shearing of rivets} = \frac{45{,}000}{9 \times \frac{\pi}{4} \times 1.06^2} = 5{,}650 \text{ lbs. per sq. in.}$$

Row II. Pull in second row of rivets is 45,000 lbs. less the amount taken away by rivet in (I); that is, the amount transmitted in row I through one rivet to the butt straps.

$$45{,}000 - 5{,}650 \times \frac{\pi}{4} \times 1.06^2 = 45{,}000 - 5{,}000 = 40{,}000 \text{ lbs.}$$

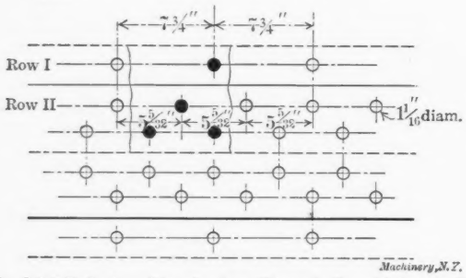


Fig. 2. Joint Redesigned to give less Stress in Row II than in Row I.

Length of plate = 7¾ — 2 × 1 1-16 inch = 5⅝ = 5.625 inches.

$$\text{Tearing of plate} = \frac{40{,}000}{5.625 \times 0.625} = 11{,}380 \text{ lbs. per sq. in.}$$

or about 5½ per cent more than in row I.

To avoid this there are two methods possible; one of them is shown in Fig. 2. Use the same pitch at row I, but increase the pitch at rows II. and III., all rivets remaining the same diameter.

Row I. Pull along one pitch = $7.75 \times 29 \times 200 = 45{,}000$ lbs.

$$\text{Tearing of plate} = \frac{45{,}000}{6.68 \times 0.625} = 10{,}780 \text{ lbs. per sq. in.}$$

$$\text{Shearing of rivets} = \frac{45{,}000}{7 \times \frac{\pi}{4} \times 1.06^2} = 7{,}275 \text{ lbs. per sq. in.}$$

$$\text{Factor of safety} = \frac{38{,}000}{7.275} = 5.22$$

Row II. Pull along one pitch = $45{,}000 - 7{,}275 \times \frac{\pi}{4} \times 1.06^2 =$ 38,575 lbs.

Length of plate = $7.75 - 1.5 \times 1.06 = 7.75 - 1.6 =$ 6.15 inches.

$$\text{Tearing of plate} = \frac{38{,}575}{6.15 \times 0.625} = 10{,}060 \text{ lbs per sq. in.}$$

or 6½ per cent less than in row I.

A second method, shown in Fig. 3, consists in increasing the pitch and diameter of rivets in the first row, or using smaller rivets in the second and third rows. Of course, this is somewhat awkward, on account of it being necessary to change the riveting tools (but on the European continent this is the usual practice) for the two sizes of rivets. If, however, we keep the 1 1-16 inch rivets in the first row, and use 15-16 inch rivets in the second and third rows, we get:

Row I. Pull along one pitch = $7.75 \times 29 \times 200 = 45{,}000$ lbs.

$$\text{Area of rivets} = \left(1 \times \frac{\pi}{4} \times 1.06^2\right) + \left(8 \times \frac{\pi}{4} \times 0.94^2\right) =$$

$0.883 + 5.550 = 6.433$ sq. in.

Length of plate = 7¾ — 1 1-16 = 6.68 inches.

$$\text{Tearing of plate} = \frac{45{,}000}{6.68 \times 0.625} = 10{,}770 \text{ lbs per sq. in.}$$

$$\text{Shearing of rivets} = \frac{45{,}000}{6.433} = 7{,}000 \text{ lbs. per sq. in.}$$

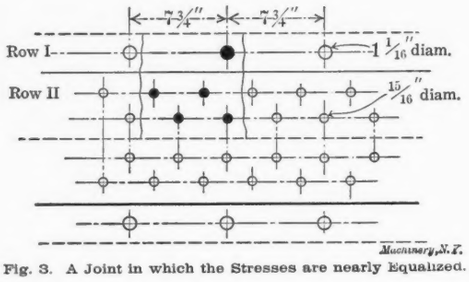


Fig. 3. A Joint in which the Stresses are nearly Equalized.

Row II. Pull = 45,000 — $0.883 \times 7{,}000 = 38{,}820$ lbs.

Length of plate = $7.75 - 2 \times$ 15-16 = 5.875 inches.

$$\text{Tearing of plate} = \frac{38{,}820}{5.875 \times 0.625} = 10{,}580 \text{ lbs. per sq. in.}$$

or 1¾ per cent less than in row I.

If instead of using smaller diameter rivets in the second and third rows we keep 1 1-16 inch rivets, but increase the diameter of rivets in the first row to 1 3-16 inch, also the pitch to give the same percentage, similar results would be obtained. In a triple butt joint with straps of equal width, the stress in the second row would always be less than in the first row; on this account therefore, it is unnecessary to make any calculations of row II.

It appears to me that here in England it is customary to use higher working stresses than in the United States; while there, according to the article, plates are used with a tensile strength of 55,000 pounds per square inch, with a factor of safety of 5, we use here plates of not less than 60,000 pounds, allowing a factor of safety of 5 for double butt joints, and a factor of safety of 4½ for triple butt joints. Here we never use iron rivets, but always steel rivets, with a shearing strength of 50,000 pounds per square inch, and a factor of safety of 5, which equals 10,000 pounds per square inch, under pressure. It is also our rule here to take the diameter of the steel rivets from $1.1\sqrt{T}$ to $1.2\sqrt{T}$, where T equals thickness of plate in inches; so that in the above case we should have used $1.2\sqrt{0.625} =$ 15-16 inches for the diameter of the rivets, and the riveting as shown in Fig. 2.

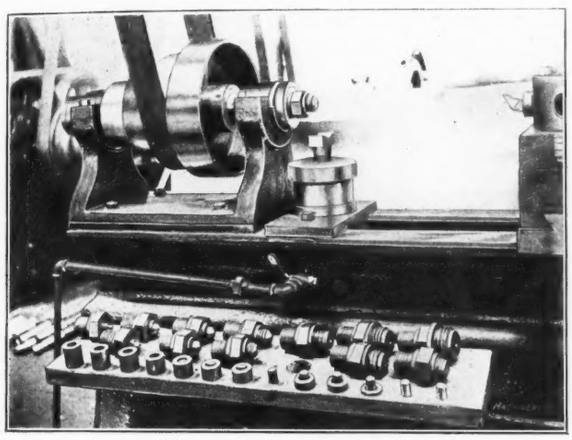
The thickness of the butt straps we take as about $0.625\ T$; the outer butt strap is in no case, however, thinner than ⅛ of the pitch in row II, as of course it would be very difficult to calk any thinner butt strap.

A. Wind.

Wolverhampton, England.

TIME-SAVING DEVICE FOR NUT FACING MACHINE.

The accompanying cut shows an addition to a nut facing machine which almost doubles its output. It used to take almost as long to remove a nut from the arbor as it did to machine it, but by the use of the air cylinder shown, placed on a block on the bed of the machine, the operator with one hand reverses the belt and with the other turns on the air which causes the piston to ascend. The top part of the piston is provided with a piece machined to fit the hexagon nut and having a projection turned to fit a hole bored in the piston rod. When the piston with this top piece reaches the nut, it grips it, and owing to the reversed motion of the spindle of the machine, the nut is quickly unscrewed. Another nut is quickly screwed on the spindle in a similar way. The air is used only to raise the piston, a spring being used to force it down. For different sizes of nuts a number of bushings are used, as shown in the lower part of the cut. These bushings are placed between the V-piece gripping the nut and the piston, in order to raise the V-block up to the required height without necessitating an excessive amount of piston

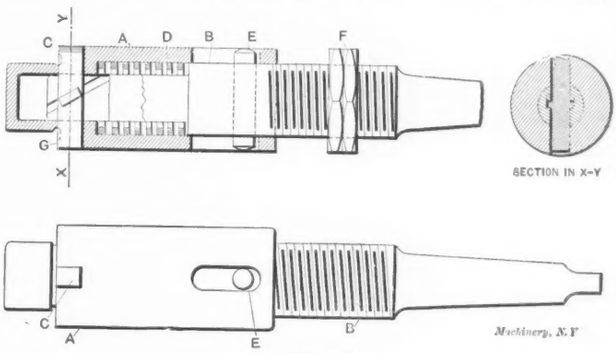


Time-saving Device for Nut Facing Machine.

travel. I am aware that there are better nut facers on the market, but this being a home-made one which serves the purpose all right, the only difficulty to be overcome was the backing off of the nuts, which can be done by the method described without stopping the machine. A little kink in connection with facing nuts which may be of benefit to some one is to face the lower side of the nut first and to have the tool ground in such a manner that the operator can slightly countersink the nut of the threaded hole. By doing this no trouble is ever experienced in getting the nut started on a bolt through the thread being burred. Another kink, when a lot of nuts come for facing which have a very hard scale, is to put them in a flue rattler, if it is a railway shop, or in any other rattler for that matter, and they will come out in as good condition as cold pressed nuts. M. H. W.

RECESSING TOOL.

The cut herewith shows a design for a special recessing tool, which can be used on an ordinary drilling machine for recessing. The tool will produce accurate results if well made. The cut shows a section of the complete tool which comprises the outer shell *A*, the center piece *B* which fits the drilling machine collet and operates the tool, the cutting tool *C*, a spiral spring *D*, a driving pin *E*, and finally two lock nuts *F*. The tool can, of course, be varied in design to suit the particular work it has to perform. The action is as follows: The piece *B*, which fits into the machine spindle, revolves the outer shell by means of the driving pin *E*. The cutting tool *C* passes through the center of the outer shell and of center piece *B*. The two side pieces on the cutting tool, shown in the section, slide in the two slots provided in the center piece. These slots are cut at a suitable angle, so that when the center piece is forced forward, the slots force the cutting tool outward until the lock nuts come in contact with the end of the shell. The nuts can be set to gage the diameter of the recess required. The end face *G* of the shell takes a bearing on the work to be operated upon. The spiral spring should be strong enough to force the center piece up, when the pressure is released at the driving spindle, to withdraw the cutting tool from the recess. When assembling the tool, care must be exercised to insure that the driving strain comes on the driving pin *E*, and that the slot at the end of the center piece does not bind on the side of the cutting tool, the function of this

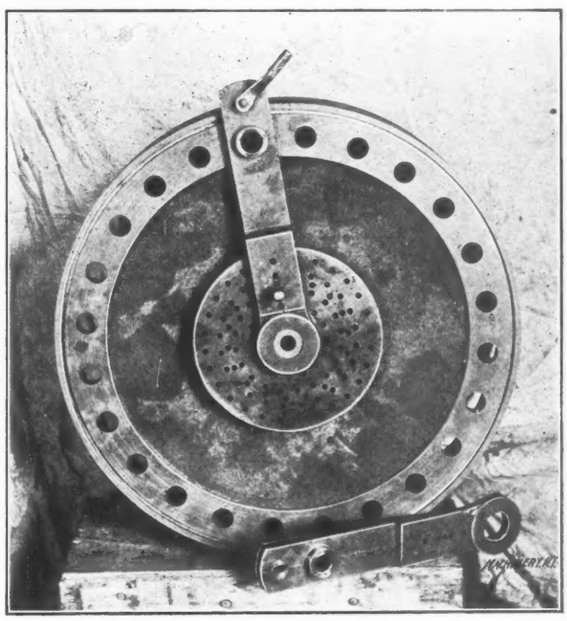


Recessing Tool.

part being only to transmit the feed to the cutting tool and not to drive it. The outer shell is the driving medium and the cutting tool should be a nice sliding fit in the shell. The slot in the shell which receives the driving pin must be a sliding fit and long enough to accommodate the full adjustment of the tool. CONTRIBUTOR.

FLANGE DRILLING JIG.

The drilling jig shown in the cut is not intended for extreme accuracy, but rather to take in a wide range of work. As the number of holes in the work to be drilled varies, it would cost considerable to make individual jigs to do the same work. The features of this jig are the individual plate, and the removable arm which carries the drill bushing. The plate is held in position by a nut on the under side of the work, and the position of the arm is fixed by a plug which



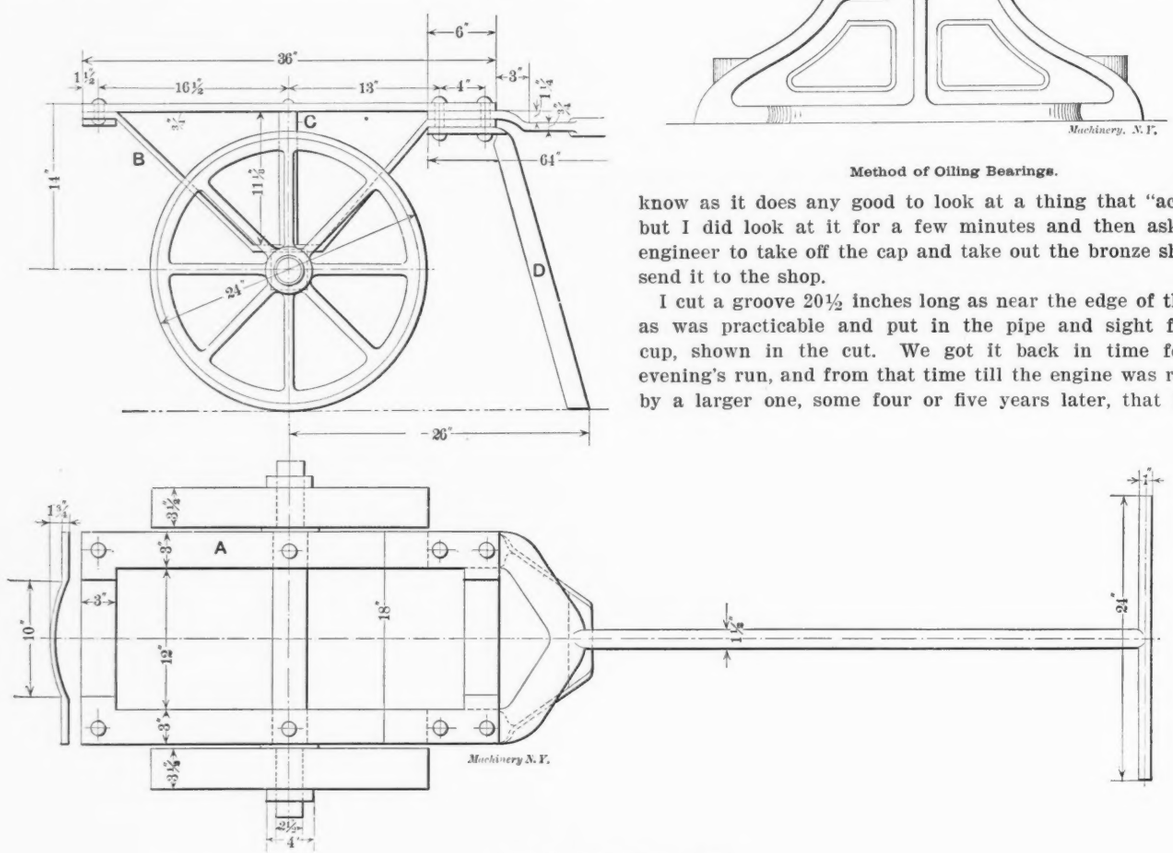
Flange Drilling Jig.

passes through the arm and into the plate. The bolt at the outer end is made of a suitable form to clamp on the under side of the work, and is tightened by the handle shown, which avoids the use of a wrench. By loosening this handle and withdrawing the locating plug, the arm can be turned to the next division, the plug inserted and the hole drilled. Different diameters may be drilled by using arms of suitable length, so the same dividing plate answers for a wide range of sizes. Although the principle of this jig is not new, yet the adaptation is entirely original so far as the writer knows.

Wellsville, N. Y. M. A. PALMER.

SLAB TRUCK FOR FORGE SHOP.

The cut herewith illustrates a slab truck that is made to handle both the hot and cold billets around a forge shop. It is made up entirely of iron, hence there is no danger of destruction when handling billets at a white heat. The height has been designed to conform to that of the furnace door and the top of the bottom die on the steam hammers in use. A heavy hot slab may be pulled from the furnace and wheeled over to the anvil of the steam hammer with greatest ease. The construction is very simple and inexpensive. The axle is made of 3 x 3-inch wrought iron, and the two wheels are 24 inches in diameter, 3½-inch tread, and made of cast iron. The slab rest *A* is made of 3 x ¾-inch wrought iron, supported by the 3 x ¾-inch braces *B*, with a piece of 1 inch wrought iron pipe *C* acting as a strut. The whole is bolted down through the axle by a ⅞-inch bolt passing through the pipe, and each end riveted over. The support *D* is of ¾ x 2-inch wrought iron made in U-shape and is very rigid. The handle is of 1½-inch round wrought iron, welded to a ¾ x 3-inch yoke. The hand bar is 1 inch in diameter by 24 inches long for the accommodation of two men. The truck as a whole has been found very useful and substantial, and since its trial many others have been constructed.

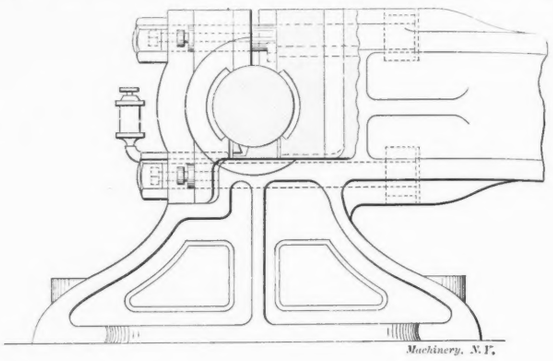


Slab Truck for the Forge Shop.

T. B. BURNITE.

OILING BEARINGS.

Having noticed several articles lately in MACHINERY about oiling bearings, I am prompted to give a bit of my experience in that line. Some 20 to 22 years ago we made an engine to run an electric light plant, with cylinder 24 x 48 inches, which was a pretty large one for our small shop to tackle. Soon after it was running, it developed an inordinate desire to heat the main bearing. This bearing was 12 inches in diameter by 21 inches long; the quarter boxes were babbitted, and the bottom shoe was of phosphor bronze 8 inches wide, giving 168 square inches to carry about 18,000 pounds, which would not seem excessive, only a little over 100 pounds to the square inch. The box was equipped with two sight feed oil cups, and had an opening on top 6 x 16 inches down to the shaft. The first regular run it made was only a few hours long—a "moonlight run"— and the engineer managed to keep it going. Soon the runs lengthened, and then the trouble grew serious. One morning after an all-night run I went over to the plant and it seemed as though there was a barrel of tallow on the floor—tallow mixed with black lead, oil, and water (only the water didn't mix), and the box was then too hot to handle. Something had to be done, and as I was practically responsible for the outfit, I felt a trifle worried. I don't



Method of Oiling Bearings.

know as it does any good to look at a thing that "acts up," but I did look at it for a few minutes and then asked the engineer to take off the cap and take out the bronze shoe and send it to the shop.

I cut a groove 20½ inches long as near the edge of the shoe as was practicable and put in the pipe and sight feed oil cup, shown in the cut. We got it back in time for that evening's run, and from that time till the engine was replaced by a larger one, some four or five years later, that bearing was never any warmer than the air in the room. As first made, this bronze shoe was beveled to carry oil under the shaft, and grooved diagonally according to the time-honored custom. We noticed one curious thing about it; if the oil cups on top were set to feeding, oil would run out over the top of the added oil cup at the left, just as much as was delivered by the two on top; stopping the oil from the top resulted in the new oil cup instantly becoming operative again. The engine ran "over"; had it run "under," I would have cut the groove at the other edge, and carried oil to it by drilling all way through the shoe.

E. S. NEWTON.

Milwaukee, Wis.

* * *

A soldering fluid which has proved very useful in certain railway shops is made, says the *Street Railway Journal*, by killing two quarts of hydrochloric acid with all the zinc it will take up. Then to the acid a quart of water is added, or it may have to be added before the zinc will fully dissolve. A quart of glycerine which has previously been mixed with a quart of alcohol is then added to the solution. This fluid is used for all kinds of soldering and has been found especially desirable with greasy or dirty connections, as well as for soldering to iron. It is claimed that the glycerine prevents the rust caused by soldering fluids containing hydrochloric acid.

SHOP KINKS.

A DEPARTMENT OF PRACTICAL IDEAS FOR THE SHOP.

Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary.

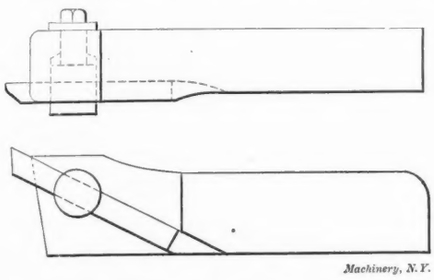
DRAFTING ROOM SCALES FOR COMPARING FULL-SIZE DIMENSIONS.

It is a good idea to have the drafting room fitted with two full-sized scales, one extending the full length, and the other the full height, of the room. These scales need not be graduated very fine—say about every quarter of a foot—but should be figured in such a manner that the figures are legible from any drawing board in the room. This scheme is being adopted quite generally in the technical schools, where the pupils are liable to have a poor conception of large dimensions, and it is sometimes a great help even to those who have had shop and field experience. E. A. PRITCHARD.

Champaign, Ill.

TOOL-HOLDER FOR THE SHAPER.

Feeling the need of a tool-holder that could be worked on a shaper right up to a shoulder without interference from the set screw, I designed the holder shown in the figure. No

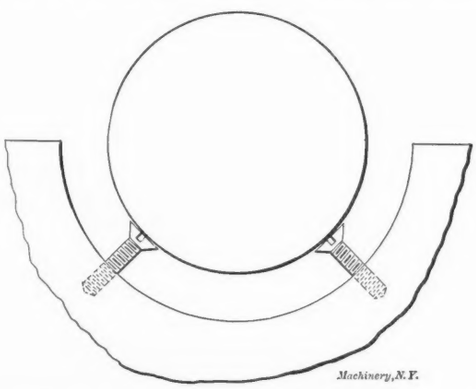


explanation is necessary, though it might be stated that the tool has not only proven successful in its intended field, but efficient for a large variety of lathe work as well.

Middletown, N. Y. DONALD A. HAMPSON.

SUPPORT FOR SHAFT WHEN BABBITTING.

In babbitting boxes for crankshafts, drill with the breast drill two holes about 90 degrees apart and about a quarter of an inch from the outside end of the boxes to be babbitted. These holes are to be tapped for small countersunk head-screws. The shaft can rest on the heads of these screws, and be lined up by adjusting the screws up or down with the fingers or a pair of pliers. After pouring the babbitt, the

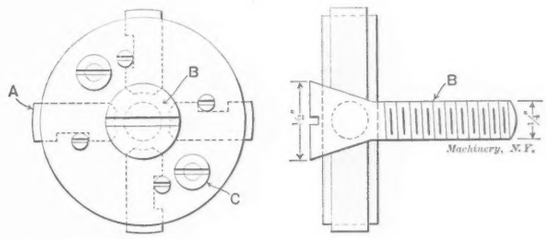


screws may be taken out with a screwdriver, or, if brass screws were used, they might be left in. One convenience of this method is, that after lining up the shaft it may be taken out of the boxes and warmed up before pouring babbitt and be replaced with the assurance that it will still be in line.

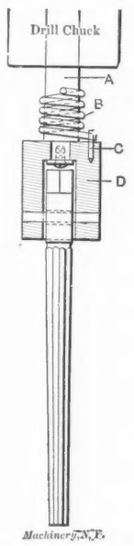
Los Angeles, Cal. STANLEY GOULD.

EXPANDING CHUCK FOR GRINDING MACHINE.

The cut herewith shows an expanding chuck for a Brown & Sharpe universal grinding machine, which I found useful in holding friction washers, etc., when grinding on the face, and I think the idea worth bringing before other readers of MACHINERY. The screw *B* fits the threaded hole in the face-plate of the machine, and, as it is screwed in, forces the pins *A* outward, thus gripping the work. The head of the screw *B* should be hardened and ground to correct taper. The pins *A* should be a good fit in the body, so as to insure accuracy. The



two screws *C* hold the body of the chuck in place, after being located in the center of the face-plate by screw *B*. The sizes of the chucks will vary according to the work to be ground, but a good many jobs can be done by just having sets of pins of different lengths. MACHINIST.



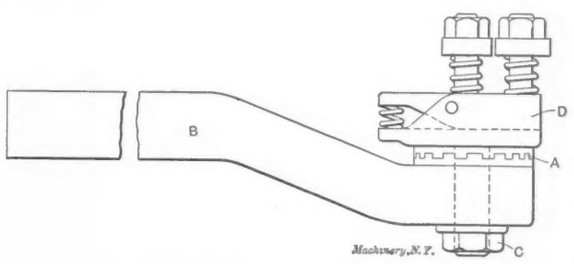
DEVICE FOR USE IN REAMING TAPER HOLES.

The device shown in the cut is handy for use when reaming taper holes on a drill press. The shank *A* is gripped in the chuck of the machine, the spring *B* is fastened to the shank at the top and has a straight portion at the lower end which engages with the driving pin *C*. The end of the shank *A* is a running fit in the body *D*, and is held by a screw and a washer as shown. The reamer is held in place by a pin, and the hole through the reamer is an easy fit, allowing some play, so that the reamer will adjust itself to the hole being reamed. The object of this arrangement is that if the reamer sticks, rather than to break the reamer, the spring will be closed up enough to permit the extending end to pass by the pin *C*, so as to leave the reamer stationary until the machine is stopped.

MACHINIST.

AN EXTENSION PLANER TOOL HOLDER.

In the cut below is shown a tool of clapper box type designed for holding tools in the planer. *B* is the shank or holder. At *A* is shown a toothed clutch secured to the tool shank *B* and the tool-holder *D*, respectively. The holder is



held to the shank by means of a nut *C*. By loosening this nut and raising the tool-holder *D*, thus disengaging the clutch, the tool may be turned to almost any angle without throwing the head of the planer over. G. E. WHITE.

Newark, N. J.

REMOVING PULLEYS FROM SHAFTS.

When a pulley or collar sticks on a shaft and will not come off, sprinkle alcohol freely around the ends and tap lightly with a hammer, which aids the alcohol to reach the part cramped. This method will also work well when a bearing binds from lack of oil. WM. DAVIS.

Philadelphia, Pa.

SHOP RECEIPTS AND FORMULAS.

A DEPARTMENT FOR USEFUL MIXTURES.

This page is intended to be used only for the publication of such shop receipts as the contributors know from experience to be practicable. Receipts are solicited on the condition that the contributors personally know that they are reliable. The fact that a receipt is old and supposedly well-known does not bar it, provided it has not already appeared here.

351. ANNEALING STEEL.

Cover the steel with fire clay, and heat to a red heat. Then allow the steel to cool over night in a furnace or forge. This method will prove satisfactory when other means fail.

Rockford, Ill. SAMUEL H. OWENS.

352. COOLING COMPOUND FOR NECKS OF ROLLS AND SHAFTS.

Dissolve 2¼ pounds of lead acetate in 14 pounds hot tallow and add 2¼ pounds black antimony. Stir the ingredients constantly until cold. W. R. BOWERS.

Birmingham, England.

353. FIRE CLAY MIXTURE.

A fire clay mixture that will stand a high temperature without cracking or checking is mixed as follows: 45 per cent crushed fire brick, 50 per cent fire clay, and 5 per cent clean, sharp sand. This is to be moistened and mixed to a heavy paste, tamped into the shape required and burned dry.

Denver, Col. E. W. BOWEN.

354. STEAM TIGHT JOINTS.

Take white lead ground in oil, add to it as much black oxide of manganese as possible and a small portion of litharge. Knead with the hand, dusting the board with red lead. The mass is made into a small roll and screwed or pressed into position, the joint being first slightly oiled with linseed oil.

R. E. VERSE.

355. STROP PASTE FOR RAZORS AND KEEN EDGE TOOLS.

An excellent strop paste for edging razors or other keen-edge tools is a mixture of levigated oxide of tin, 1 ounce; powdered oxalic acid, ¼ ounce; powdered gum, 20 grains. Mix to a paste with water, spread evenly over, and work well into the strop with some smooth surface. The rough side of the strop gives best results. E. W. BOWEN.

Denver, Col.

356. METAL POLISH.

Get two or three oyster or clam shells and burn them on clear coal fire for fifteen or twenty minutes; then powder them in a mortar. This makes a superior metal polish. It is the best thing I have ever used for polishing silver and gold articles, and if finely pulverized can be used on the most delicate article without injury. REX MCKEE.

Joliet, Ill.

357. WASH FOR WHITENING METAL WORK FOR LAYING OUT.

Mix whiting and white lead with boiled linseed oil to a thick paste; add some Japan dryer, and thin with benzine or gasoline. This makes a fine preparation for whitening sheet iron and other work previous to laying out, as any lines drawn on the surface show up very distinctly. It also makes a very good stenciling or marking paint. A. D. KNAUEL.

Moline, Ill.

358. TO PREVENT GLUE CRACKING.

A useful fact to know in regard to glue when using it on furniture or other work that will be exposed to a very dry atmosphere, is that a small addition of chloride of lime will tend to prevent the glue drying out and cracking. The chloride of lime is strongly hygroscopic and constantly attracts enough moisture from the atmosphere to keep it moist. Use about one-fourth ounce of chloride to one quart of glue.

M. E. CANEK.

359. LUBRICANT FOR TURNING COPPER.

Having noticed that in the Shop Receipts in the March issue it is stated that milk is a good lubricant for use in turning copper, I would like to mention another which is perhaps more easily procurable, or rather more apt to be on hand, in a machine shop. This is gasoline. In our shop we have used gasoline as a lubricant for cutting copper with very good results. GEORGE C. NASH.

Rockford, Ill.

360. TO WATERPROOF LEATHER.

To waterproof leather and leave it soft and pliable, apply a mixture of 4 parts castor oil and 1 part raw india rubber, by weight. Heat the oil to 250 degrees F., then add the rubber, cut into small pieces. Gradually stir until the rubber is completely dissolved and then pour into a suitable vessel and let cool. If used on dark leather add sufficient printer's ink to give the dark color. E. W. NORTON.

361. LIQUID METAL POLISH.

A good liquid metal polish for cold smooth surfaces, either iron or brass, may be made from the following ingredients: To 3 quarts of benzine add 2 ounces of oxalic acid and 1½ pound of silicate acid powder. This polish may be made in large quantities and set aside for further use provided it is kept in tightly closed bottles, and shaken well before using. Apply the solution with a piece of cloth. When dry, polish with a soft, clean cloth. T. E. O'DONNELL.

Urbana, Ill.

362. CEMENT FOR FASTENING METALS TO GLASS.

Melt together in a water bath 15 parts of copal varnish, 5 parts of drying oil, and 3 parts of turpentine. When the ingredients are well mixed add 10 parts slacked lime. An elastic cement for fastening brass to glass may be made by mixing 5 ounces of resin, 1 ounce beeswax, and 1 ounce of red ochre or venetian red in powdered form. Melt the resin and beeswax together by gentle heat, and gradually stir in the venetian red. W. R. BOWERS.

Birmingham, England.

363. POLISH FOR BRASS.

An excellent liquid polish for articles of brass may be made as follows: Add together and mix thoroughly, 100 parts of powdered pumice stone, 2 parts oil of turpentine, 12 parts soft soap and 12 parts of fat oil or lard. When thoroughly mixed, add the mixture to a solution of 3 parts oxalic acid dissolved in 40 parts of hot water. Stir well until a uniform paste is formed. Apply to surface of any article of brass, by means of a cloth, rubbing it in well. Remove remnant and polish with a clean, dry cloth. T. E. O'DONNELL.

Urbana, Ill.

364. TO CASE-HARDEN FOR COLORS.

Mix 10 parts charred bone, 6 parts wood charcoal, 4 parts charred leather and 1 part of powdered cyanide potassium. Clean the work thoroughly, and do not handle with greasy hands. Pack the work with the mixture in a common gas pipe plugged at one end, and seal at the other with asbestos cement. Heat in a furnace to a dark cherry red and keep at that heat for about 4 or 5 hours. Dump in a tank with compressed air bubbling up through the bottom. If the colors are too gaudy leave out the cyanide. J. F. SALLOWS.

Grand Rapids, Mich.

365. PASTE METAL POLISH.

A paste metal polish that is good for any smooth surface, whether hot or cold, can be obtained from the following ingredients, which will make about 20 pounds of the polish: 2 ounces of spermaceti, 4 ounces of cake tallow, 10 star candles, 2½ pints of raw linseed oil, 2½ pints of kerosene, and 5 pounds of tripoli powder. Procure a crock that will hold 3 or 4 gallons. Put in the tallow, spermaceti and candles, and melt over a slow fire. Then add the linseed oil and kerosene, and stir well. While this mixture is still warm, remove from the fire, and add the tripoli powder very slowly while constantly stirring the mixture. When all the powder has been added, allow to cool. To use, apply with a soft cloth, and after drying, remove the remnant and rub the surface with a piece of soft flannel. T. E. O'DONNELL.

Urbana, Ill.

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

MAKING GEARS TO BROKEN SAMPLES.

J. H.—Suppose I am given the task of making a gear of any kind, and am given a sample gear that is broken in several pieces, so that it would be impossible to caliper it or measure it in any other way. How can I get the exact dimensions by calculation to make a new gear? I want to know the outside diameter, pitch diameter, thickness of tooth, etc.

A.—If the broken gear is of an even diametral pitch the problem is a simple one. In the Brown & Sharpe catalogue will be found a series of silhouetted profiles of gear teeth, of various diametral pitches. These will be found in other books relating to gearing as well. A tooth of the broken gear may be matched up with these drawings until it is found what pitch the original gear was. Then add 2 to the number of teeth in the broken gear, and divide by the diametral pitch found. This will give the correct outside diameter. Divide the number of teeth by the diametral pitch, and the answer will be the pitch diameter of the gear. Divide 1.5708 by the diametral pitch, and the result will be the thickness of the tooth at the pitch line. Divide 2.1571 by the diametral pitch, and the result will be the total depth of the space, or the depth of cut required. All the dimensions thus obtained are in inches. For example, a broken 30 tooth gear is found by comparison with the catalogue cuts to be 4 diametral pitch. The outside diameter is then $(30 + 2) \div 4 = 8$ inches. The pitch diameter is $30 \div 4 = 7\frac{1}{2}$ inches. The thickness of tooth at pitch line is $1.5708 \div 4 = 0.3927$ inch. The whole depth of tooth is $2.1571 \div 4 = 0.5393$ inch.

QUESTIONS OF STRENGTH OF MATERIALS, ECCENTRIC LOADING.

A. W.—1. Fig. 1 represents a wrought-iron bar with an offset of $3\frac{1}{4}$ inches. This is a draw-bar between a locomotive and tender. Please tell me how to calculate the fiber stress in this piece. Of course, it would not stand as great a strain as it would if it were a plain straight bar of the same section. It is subject to a pull of 21,600 pounds. 2. The sketch, Fig. 2, shows a load suspended at the end of a boom, which is in turn suspended from the tie-rod or guy rope shown. What will be the strain in the boom and the guy rope if weight W weighs 5,000 pounds, and what formulas would be used in solving this?

A.—1. You are right in surmising that the fiber stress in the bar is greater when it is bent as shown than it would be if it were straight. This is because a bending strain is introduced in the offset portion. This bending strain may be expressed in inch-pounds by multiplying the load in pounds by the amount of offset in inches. Fig. 3 shows the principle. The stress in the offset portion of the bar is the same as if it were broken off, as shown, and the load were applied to a clamp or bracket, the point of application being in line with the original center line of the load. It is easy to see in this case that a bending moment of Px inch-pounds is set up, tending to bend and break the bar where it is fastened to the clamp. Considering the bar, then, as a beam subject to a bending moment of Px inch-pounds, we have for fiber stress

$$S = \frac{Mc}{I}$$

in which S is the unit fiber stress.

I is the moment of inertia of the section.

c is the distance from the netural axis of the section to the outermost fiber in the plane of bending.

The moment of inertia for a rectangular section equals the width multiplied by the cube of the height, divided by 12; or, $4 \times (2\frac{3}{8})^3 \div 12 = 4.46$.

$M = Px = 21{,}600 \times 3\frac{1}{4} = 70{,}200$ inch-pounds.

$c = \frac{2\frac{3}{8}}{2} = 1.18$, about.

Inserting these in the formulas first given, we have

$$S = \frac{70{,}200 \times 1.18}{4.46} = 18{,}700 \text{ pounds per square inch.}$$

This is the unit tensile stress due to bending. Besides this we have that due to direct tension, which is found by dividing the load by the area of the section. This gives us $\frac{21{,}600}{4 \times 2\frac{3}{8}} = 2{,}270$ pounds per square inch. The maximum fiber stress will then be equal to the sum of these two, or $18{,}700 + 2{,}270 = 20{,}970$ pounds per square inch. Another case

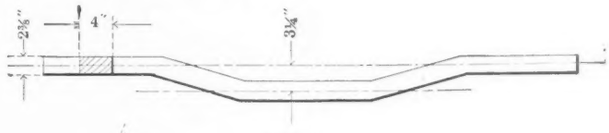


FIG. 1

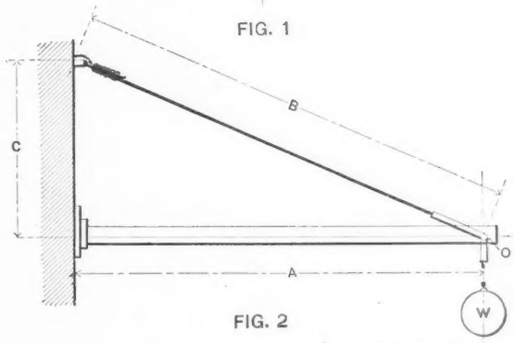


FIG. 2

Machinery, N.Y.

of the same kind is shown in Fig. 4. In this, or any other case, a straight line may be drawn between the two points where pressure is applied. If, then, the neutral axis be drawn, the point where the distance between the neutral axis and the pressure line is greatest will be the point where the bending moment is greatest. The distance between the lines at this point, shown by x in Fig. 4, will be the lever arm of the bending moment, which will be expressed as Px, the same as in Fig. 3.

2. This problem can be simply solved by the parallelogram of forces. Draw a diagram like that shown in Fig. 5 in

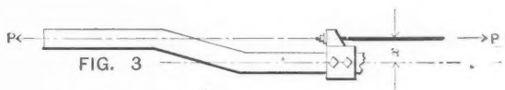


FIG. 3

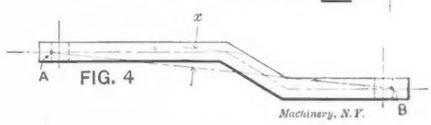


FIG. 4

Machinery, N.Y.

which F_1 is parallel to the pull of the weight (which, of course, is vertically downward), F_2 is parallel to the direction of the beam or compression member, and F_3 is parallel to the guy rope. Make F_1 of a length representing to scale the weight of the load. Complete the parallelogram determined by the length and position of F_1, and the directions of F_2 and F_3. F_2, measured to the same scale as F_1, will then give the compressive stress in the boom, while F_3 will give the tensile stress in the guy rope. Calling the side of the parallelogram

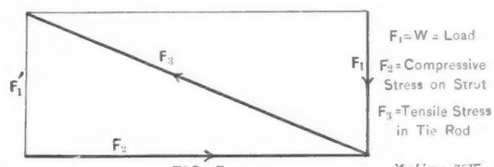


FIG. 5

Machinery, N.Y.

opposite F_1 by the symbol F'_1, and noting that F_1 and F'_1 are equal and parallel, it will be seen that the triangle enclosed between F'_1, F_2 and F_3 is similar to that included between the center lines of the guy rope and the boom, and the wall to which they are fastened. From this we may derive the following simple formulas in which

S_a = the compressive stress in the boom,

S_b = the tensile load on the guy rope or tie rod,

$$S_a = \frac{F_2 W}{F'_1} = \frac{A W}{C} \qquad S_b = \frac{F_3 W}{F'_1} = \frac{B W}{C}$$

NEW MACHINERY AND TOOLS.

A MONTHLY RECORD OF APPLIANCES FOR THE MACHINE SHOP.

BROWN & SHARPE NO. 4B PLAIN MILLING MACHINE.

The No. 4B heavy plain milling machine shown in the accompanying half-tones and line cuts is one of the latest products of the Brown & Sharpe Mfg. Co., of Providence, R. I. It has the same feeding range, horizontally, vertically and across, as the older machine of the same number, but weighs much more, and has been built with a single pulley geared drive. The machine is, in fact, entirely new in all its parts, improvements having been made in every detail.

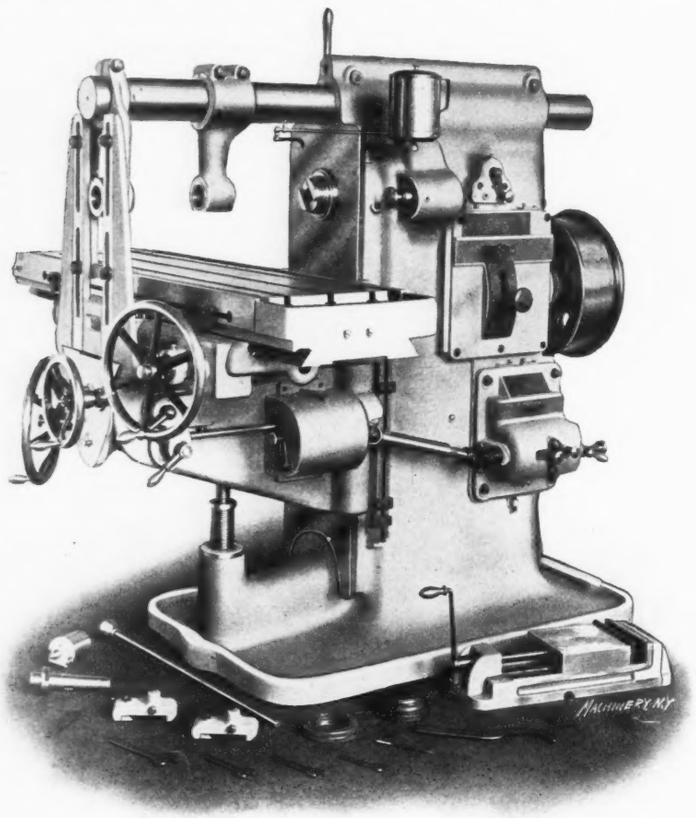


Fig. 1. Brown & Sharpe No. 4B Plain Milling Machine.

The advantages of the constant belt-speed drive for the milling machine, with the feed taken from the driving shaft, are too well understood to need elaboration. The line cut, Fig. 3, shows the mechanism used for changing the spindle speed on this machine. Driving pulley *A* is 18 inches in diameter for a 6-inch belt. It is very heavy and serves as a balance wheel to give steadiness of motion to the cutting spindle. It drives constant speed shaft *B* and driving pinion *C*. Gears *FFFF* rotate together on the shaft on which they are mounted. Either of these four gears may be connected with pinion *C* by an intermediate, not shown here, which is shifted longitudinally to match either of them and brought into mesh by the two knobs shown on the front side of the column in Fig. 1. A further change is obtained by a handle above them which rotates pinion *J*, shown in Fig. 3. This pinion meshes with circular rack teeth cut on the hub of double gear *H*. By this means, either the 31 or 47 tooth end of gear *H* may be engaged with the corresponding gears *FF* below it. Eight speeds are obtained by the mechanism shown. A further change is effected by what corresponds to the back gears of the ordinary milling machine. These are operated by a handle attached to an ordinary eccentric back-gear supporting shaft, which, however, is connected with a mechanism which automatically throws the main driving gear on the spindle out of mesh with the driving sleeve, a stopping of the machine and manipulation of lock bolt, etc., at this place not being required.

The rigid support of the spindle should be noticed. The upper part of the frame is entirely enclosed, making a stiff structure, and this rigidity is enhanced by the extension of the knee slide at the front of the column to the top of the machine. This extended knee slide also makes it possible to clamp any of the regular attachments directly to the face of the column in such a way that they become practically a part of the machine.

The spindle drive used is especially adapted to direct connection with a motor. Finished pads are provided on the machine so that the change may be made at any time without requiring any machine work to be done. Unless otherwise specified, the chain sprocket which replaces the driving pulley *A* in this case is connected to driving shaft *B* by a friction clutch, so that the machine may be started and stopped without recourse to the electric controlling mechanism. This scheme may also be used for the belt drive, in cases where it is desired to connect the machine direct with the line shaft without the intervention of a countershaft. Where it is desired to use a variable speed motor, the spindle driving gearing is much simpler than that shown, four changes only being obtained mechanically. The same total ratio of about 20 to 1 is still maintained in that case.

Other points of interest can be picked out from Figs. 3, 4 and 5, made from blue-prints kindly furnished by the makers. It will be noted that the table is very heavy and has great vertical depth, giving it unusual stiffness. The working surface has been greatly enlarged over the former machines of the same size. It has a quick return and slow speed longitudinal feed, operated by the same hand-wheel *O* in Fig. 5. The change is obtained by operating knob *N*, which is attached to clutch *P* as shown.

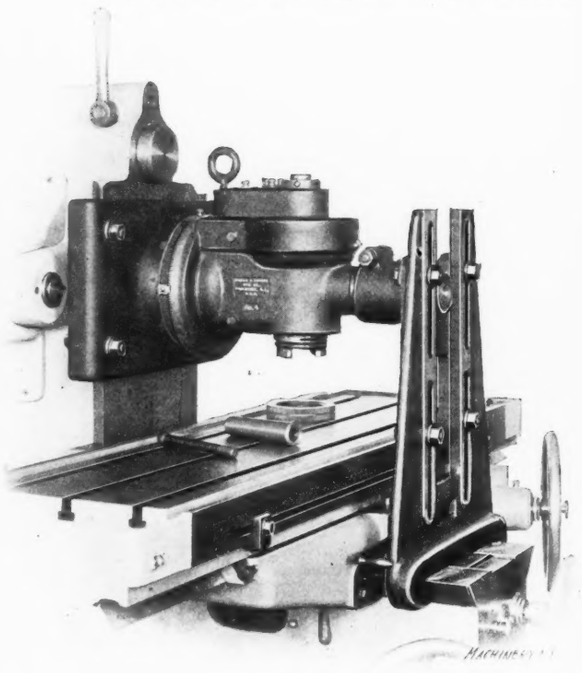


Fig. 2. Vertical Attachment for New Design of Milling Machine.

The hand-wheels for the three adjustments are all permanently attached to the machine and can be operated together

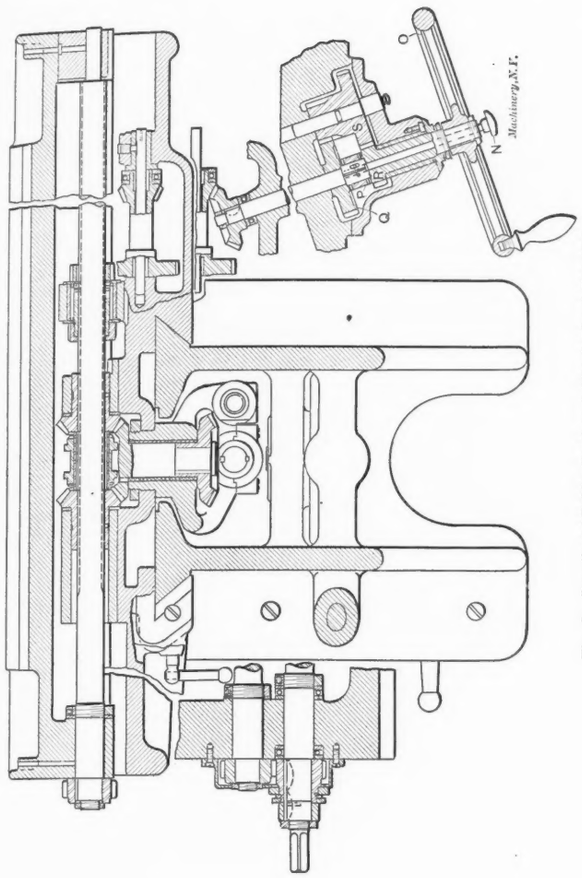


Fig. 5. Details of Table Feed and Hand-wheel Gearing.

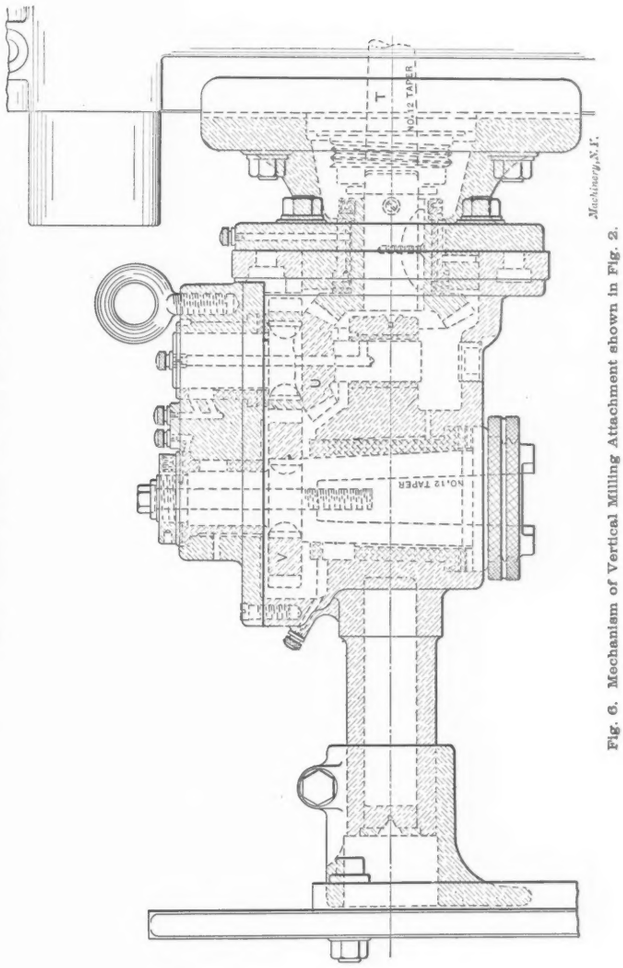


Fig. 6. Mechanism of Vertical Milling Attachment shown in Fig. 2.

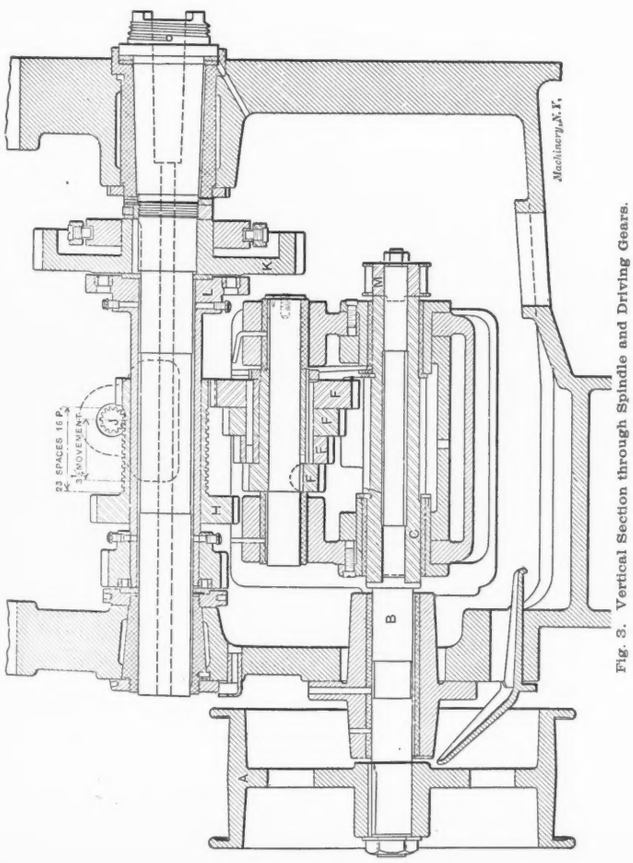


Fig. 3. Vertical Section through Spindle and Driving Gears.

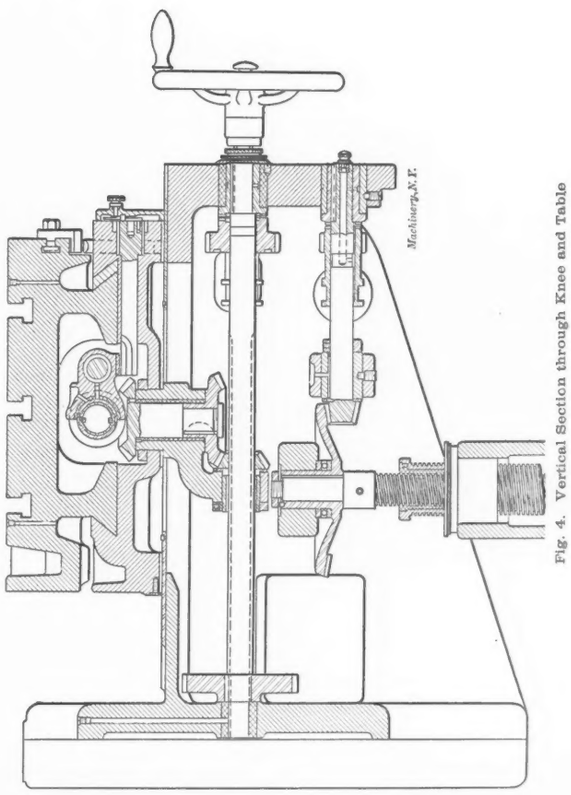


Fig. 4. Vertical Section through Knee and Table

without interference. They are all provided with throw-out clutches to disengage them after the adjustment is made, and all have dials graduated to read to 0.001 inch.

Sixteen changes of feed are obtained by the quick change gear mechanism supplied with the machine. The drive is by spur gears entirely, connected with the constant speed shaft of the driving pulley. An automatic tripping mechanism is supplied for all three feeds. When desired, the machine may be simplified by having only the longitudinal feed automatic. Suitable oil pans and channels are provided. When an oil pump is furnished, provision is made to carry the oil into the saddle and then to the tank, thus doing away with the long piping necessary to follow the movement of the table.

The machine shown has a longitudinal feed of 42 inches, a cross feed of 12 inches, and a vertical feed of 20 inches. The table working surface is 57¾ inches by 19 inches with three ¾-inch T-slots. The net weight of the machine is approximately 8,200 pounds.

The vertical attachment for this machine is shown in the halftone, Fig. 2, and the line cut, Fig. 6. It is proportioned to carry any cut within the pulling capacity of the main driving belt. Attention is called to the arrangement of the driving gears, which allows an unusual amount of spindle bearing, almost as large as that employed for the main spindle of the machine, thus insuring rigidity under the most severe service. The drive is from the main spindle of the machine by a clutch arbor *T*, through bevel gears to intermediate gear shaft *U*, then to spur gear *V* on the vertical spindle. This spindle has the same size taper hole and is threaded to the same diameter as the machine spindle. This allows the use of the same size collet chucks, face mills, etc., on either the machine or attachment spindle. All bearings are bushed with bronze and all gears are of steel, hardened and proportioned to transmit the full power of the main driving belt. The frame of the attachment is clamped directly to the face of the knee slide, and has an outer support to insure additional rigidity. It may be adjusted to any angle in a vertical plane. It weighs about 500 pounds.

DALLETT MOTOR-DRIVEN BOILER SHELL DRILL.

This machine consists, as shown in Fig. 2, of two end housings, on whose front face, carried by brackets, are two 5-inch bars supporting two independent motor driven drill heads, adjustable lengthwise on the bars. The brackets carrying the bars and the drill heads have a vertical adjustment of 6 feet. They are raised and lowered by means of screws actuated by a motor on the top rail of the machine. The machine is used in the usual way for drilling the rivet holes in boiler shells, the work being mounted on rolling supports in front of the drill spindles, which are adjusted to the proper vertical height. By rolling the shell and shifting the spindles longitudinally, any point in the bearing surface of the boiler may be reached. The machine is designed for the special purpose of taking advantage of the possibilities of high speed steel.

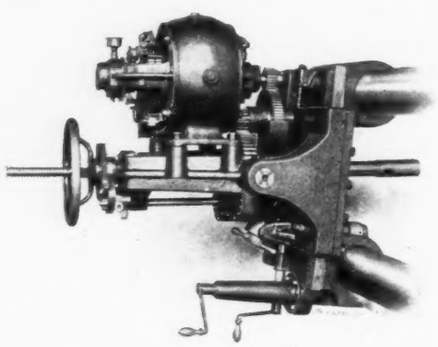


Fig. 1. Spindle Driving Mechanism of Dallett Drill.

Fig. 1 shows the design of the drill heads to the best advantage. Each is mounted on trunnions, and has a vertical adjustment in itself of 6 inches, operated by a crank handle at the bottom. It is moved on the bars by a rack and pinion on the under side of the lower bar. The variable speed motor is connected to the drill spindle by spur gears entirely, and gives a range of from 80 to 160 revolutions per minute. The spindle is bored for a No. 4 Morse taper. It has a traverse of 18 inches, and an angular adjustment on the trunnions of 15 degrees, to permit drilling rivet holes radially to the center of the boiler when the heads are not raised exactly to the proper height. This angular adjustment is controlled by the hand-wheel shown immediately beneath the driving gears. An especially valuable feature of the machine is the central position of the spindle, not only between the bearings of the drill head and the bars, but also between the bars themselves, so that the pressure of the drill against the work has no tendency to set up sidewise strains in the bearings of the drill heads or brackets.

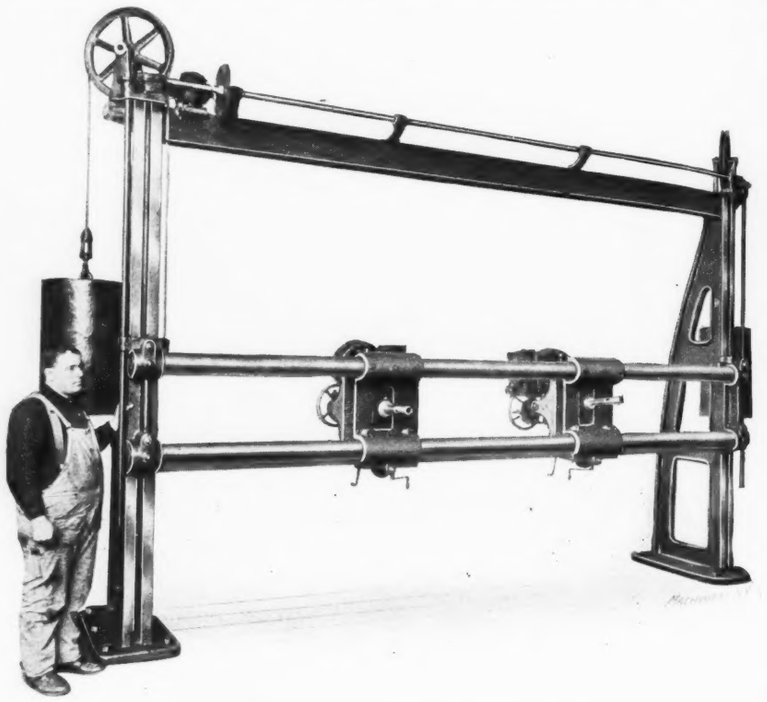


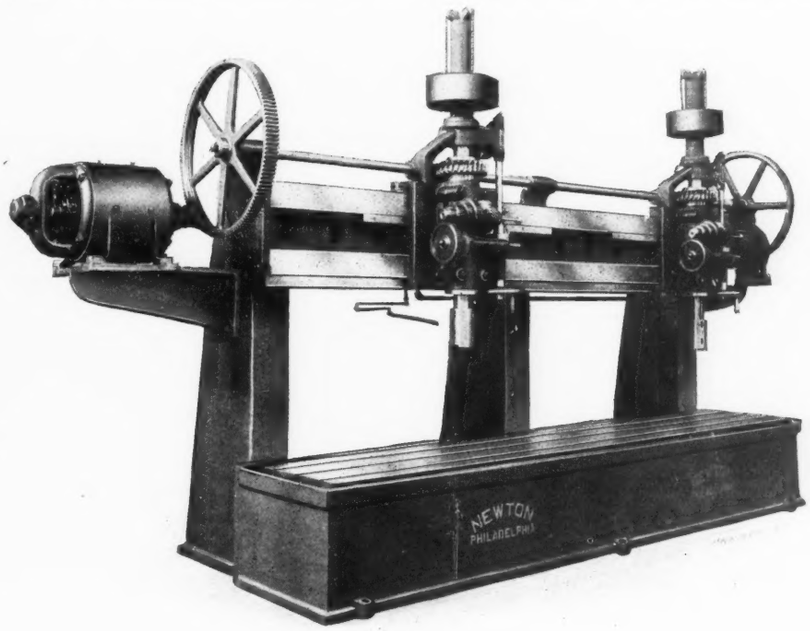
Fig. 2. Dallett Motor-driven Drill for Rivet Holes in Boiler Shells.

The feeding mechanism is of the ratchet type, adjustable to give from 0.005 to 1/16 inch per revolution. This range of feeds covers entirely the requirements for drilling in boiler work. The connecting rod between the adjustable crank and the rocker plate is fitted with a spring which can be set for any pressure of feed. It is impossible for this pressure to be exceeded, as the spring compresses when the limit is reached, and the feed ceases to operate until the pressure is reduced, thus providing an automatic release in the case of overloading the drill.

The machine is entirely self-contained, all adjustments being obtained by crank handles, no wrenches being required. The operator has all the adjustments of the drill head at his command at either side, without moving from his position. In the lowest position of the carriage, the center line of the spindles is 21 inches from the floor, and in its highest position 7 feet 6 inches. The distance between the housings is 14 feet, and the distance between spindle centers when the drill heads are in their outer position is 12 feet. The total weight of the machine is 12,000 pounds. The machine is built by the Thos. H. Dallett Co., 23d and York Sts., Philadelphia, Pa.

DOUBLE SPINDLE ROD BORING MACHINE.

The Newton Machine Tool Works, Inc., of Philadelphia, Pa., has recently furnished the Altoona shops of the Pennsylvania R. R. with the new design of double spindle boring machine which is shown in the accompanying half-tone. This machine is designed for finishing parallel rods and similar parts occurring in the manufacture and repair of locomotives. An interesting feature of the tool is the method by



Double Spindle Boring Machine for Parallel Rods, Etc.

which the spindles are driven. There are two spindles, and a motor is provided for each. These motors, mounted on brackets bolted to the columns at either end of the machine, are geared with a large reduction to splined driving shafts, on which are mounted the worms which drive the worm gears on the spindles. A casual glance at the cut would give the idea that the driving shaft above the cross rail of the machine is a continuous one; but each half of it is in reality separate, the two ends having a common bearing in the central bearing support. The motors are furnished by the General Electric Co. They are of 7½ horse-power, and have a speed range of from 500 to 1,500 revolutions per minute.

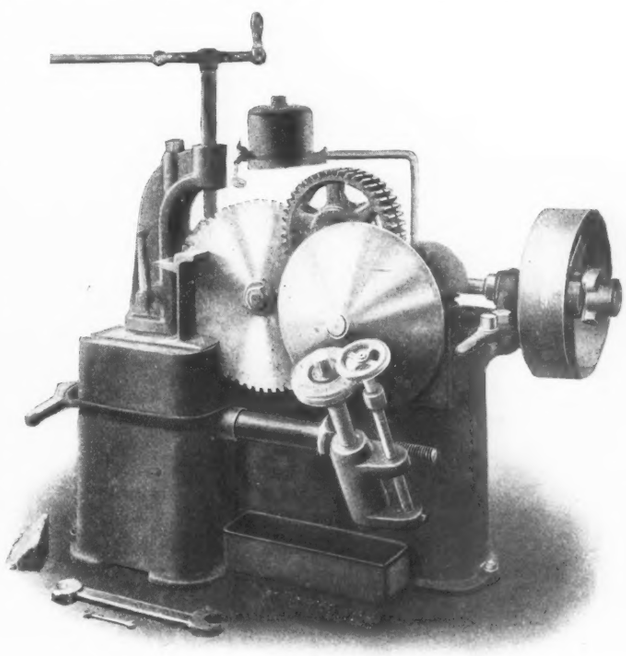
The cross rail is supported on three columns, as shown. It is of the hollow box type and serves as a reservoir for the lubricant used. The work table is 24 inches wide and 13 feet 6 inches long over the working surface, and is entirely surrounded by an oil channel. The two saddles are gibbed to the rail with brass taper shoes. They have a horizontal hand adjustment, permitting a range of from 4 feet between centers of spindles, to a maximum distance of 11 feet 9 inches. The distance from the bottom of the spindle to the top of the work table is 26 inches at its maximum. The driving worm-wheels are of bronze, meshing with hardened steel worms of steep pitch. As is clearly shown in the illustration, the feed is taken directly from each spindle by means of spiral gears, making the feed dependent on the motion of the spindle to which it is attached. This, with the separate drive provided for the two heads, permits the selection of the proper speed and feed for each tool independently of the other. The spindles are counterbalanced and four geared feed changes are provided.

QUINCY, MANCHESTER, SARGENT CO.'S METAL SAWING MACHINE.

The cut shows a new type of metal saw which has been recently added to the line built by the Quincy, Manchester, Sargent Co., of 90 West Street, New York. It is designed to meet a demand for a somewhat smaller machine than those of the standard line, which will yet exhibit all the strength and wearing qualities of the regular construction at a price within the reach of small shops, whose work does not warrant the expense of the heavier and more elaborate machine. The size shown is especially desirable for shops that have a large amount of round and square shapes to cut.

The saw blade is similar to that used on the "Bryant" type of machine, built by the same makers, being driven from its periphery rather than from the arbor. Instead of having a sprocket drive, however, steel rollers are used. These are hardened and ground and journaled in removable steel bushings which are held securely in the double driving gear which spans the saw blade, as shown in the cut. These rollers reduce the friction of the drive, and make repairs less expensive as well, since a roller can be easily replaced when it is worn or broken. The driving gear with its driving rolls can be adjusted toward or away from the center of the saw to give the right amount of back lash and proper action. By this method of drive, a much larger diameter of blade is available for cutting than can be obtained from one of the same size, arbor driven, in which case about one-third of the diameter is necessarily occupied by the driving collars.

The saw is carried on a tool steel arbor hardened and ground to standard size. The bearings of the saw arbor and all other shafts are either bronze bushed or babbitted. The carriage in which the saw arbor is mounted has the gib located on top of the ways on which it slides, so that no strain comes upon it other than that of keeping the carriage in position. This arrangement, which is similar to that used on the connection between the saddle and rail on a planer, makes the machine very rigid and free from vibration.



Quincy, Manchester, Sargent Co.'s Metal Sawing Machine.

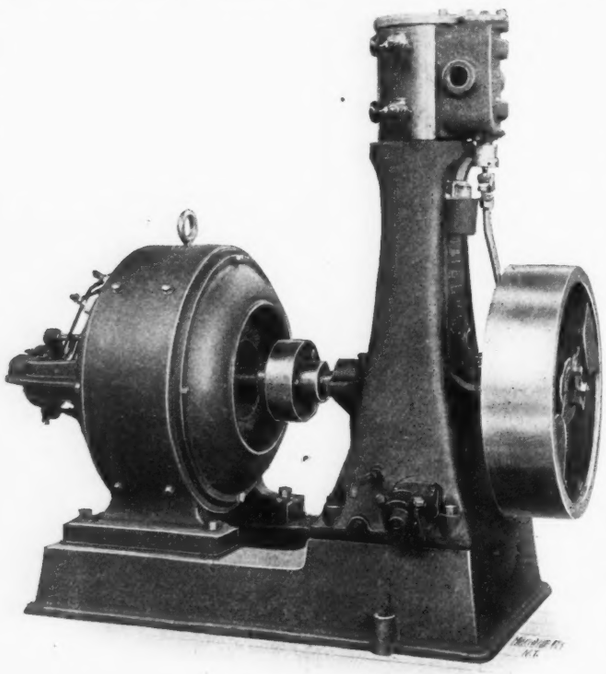
The feed is of the friction type, instantly adjustable, while the machine is in motion, to give from 3-16 to 1 inch per minute movement. It is greatly superior to a ratchet feed, which is necessarily intermittent in its action. The wheel shaft has a hardened worm and is supported in roller bearings. It meshes in a bronze worm-gear threaded to receive

the feed screw, which is held stationary when feeding by a latch pin, the worm-gear acting as a nut. To return the carriage, the latch pin is raised, and the handle attached to the feed screw operated by hand. This feed arrangement adds greatly to the simplicity of the machine and its consequent ease of operation, as well as being inexpensive.

The front table is of sufficient size to enable beams and channels to be properly held when being cut off at any angle up to 45 degrees. The holding device and driving power of the machine have a capatity for round stock up to 6 inches in diameter, square stock 6 inches on the side, and I-beams up to 10 inches in vertical dimensions. The driving pulley, which runs at a normal speed of 130 revolutions per minute, is 16 inches in diameter for a 3½-inch belt. The saw blade is 18 inches in diameter and 3-16 inch thick. The machine is furnished complete with two saw blades; special gages to cut duplicate parts; V-blocks of suitable size to center the largest diameter stock the machine is listed to cut; a clamp bracket large enough to hold any material up to the capacity of the machine; and the necessary wrenches. When desired the machine will be furnished arranged for direct-connected motor drive. The weight of the machine, mounted on skids for shipment, is approximately 1,500 pounds.

STEAM ENGINE GENERATOR SET FOR SMALL INSTALLATION.

The Robbins & Myers Co., of Springfield, Ohio, has brought out, in conjunction with the American Blower Co., the direct-connected steam engine generator shown in the accompanying cut. The engine was described in the February, 1905, issue of MACHINERY. As there stated, special pains have been taken to make the machine take care of itself, especially as relates to oiling and adjustment. A rotary pump, shown at the front of the base of the machine in the cut, is used to provide a steady



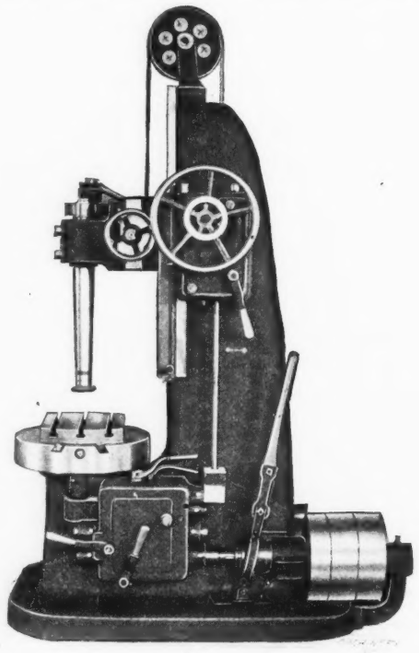
Robbins & Myers Generator for Direct-connected Service.

and sufficient supply of oil for all the parts requiring it. Tests in actual practice have proven that the engine will run several months without oiling or adjustment. The engine has a shaft governor, as shown.

The generator is one of the builders' protected type of machines of the line known as the "Standard." For use with the outfit shown, it is made in three sizes, 5, 6 and 8 kilowatt capacity each.

SAXON VERTICAL CYLINDER GRINDER.

The vertical cylinder grinder shown in the cut is built by the Saxon Machine Co., of Holyoke, Mass. It is designed for internal grinding gas and gasoline engine cylinders, air compressor cylinders, etc., and other holes which must be true, carefully aligned, and accurately finished. It is also convenient for external grinding of pins, bushings, pistons and similar work. It is built on the lines of the boring mill. The advantages of grinding cylinders in a machine of this type, instead of finishing them by boring, are that there is no springing of the tool away from hard spots or digging in at soft places; thin cylinder walls are not distorted, and there is no deflection of the tools in passing the port holes; duplex cylin-



Saxon Vertical Cylinder Grinder.

ders can be ground without resetting, thus insuring close alignment; and there is less danger of scoring when working in the cylinder with the piston.

The column is heavy and stiff, even beyond what would seem to be actually required. The bearing surface of the cross rail and face-plate are unusually large. The grinding head is adjusted for diameter on the cross rail by a screw having a dial graduated to thousandths of an inch. The vertical travel of the head up and down is automatic, being controlled by reversing dogs. There are six different feeds for each speed of rotation, varying from 1/32 to 5/16 inch per revolution. The wheel spindle is driven from a vertical shaft beside the grinder, and its bearings are of a special metal, adjustable and protected from dust.

The face-plate has large bearing surfaces, thoroughly safeguarded from emery. It is provided with two sets of three T-slots each, crossing each other at right angles. A special form of table (shown in the cut) may be used for duplex cylinders. This permits the work to be adjusted from one bore to the other without loosening it from its settings. The table has eight speeds, ranging from 7 to 41 revolutions per minute. The driving shaft is fitted with tight and loose pulleys, and is driven directly from the main line. No countershaft is required. A motor can be directly connected to the grinder when desired.

The machine will grind internal work up to 13 inches in diameter by 18 inches long, and external work up to 6 inches in diameter by 18 inches long. The grinding wheel ordinarily used is 3½ inches in diameter. The face-plate is 20 inches in diameter. The net weight of the machine is about 3,250 pounds. Attachments for the use of water and an exhaust fan for removal of the dust (not included in the regular equipment) will be furnished when desired.

TOLEDO PRESSES AND DIES FOR THE MANUFACTURE OF BATH TUBS.

This article describes an unusual and interesting outfit of machinery and tools, furnished by The Toledo Machine & Tool

Co., of Toledo, Ohio, for producing seamless stamped steel bath tubs. This outfit represents what is believed by its builders to be the largest set of tools yet furnished in this country for producing deep drawn work by the toggle press method. The work is done cold and is completed in only three operations, in such fashion as to avoid all wrinkling and distortion of the finished product. The stamping is an-

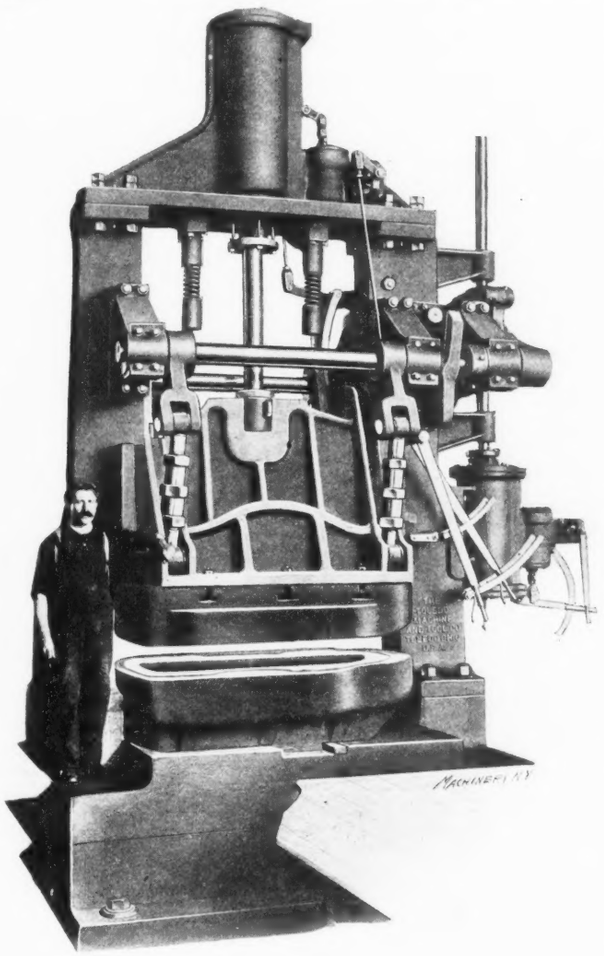


Fig. 1. Steam Actuated Toggle Press for Heavy Stamping and Forming.

nealed but once during the course of manufacture, and this annealing is required only to restore ductility to the rim, to prevent the possibility of fracture when trimming and forming in the third operation.

The press shown in Fig. 1 is the first machine employed. While it is very large and heavy, owing to its special design it is of much less weight than would be required with the usual form of toggle drawing press for small work of a

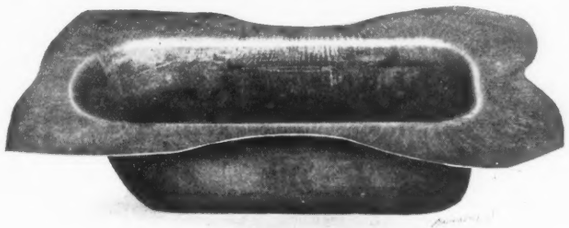


Fig. 2. Work at the Conclusion of the Second Operation.

similar nature. The movements are controlled by two direct-connected steam cylinders, one for the holding die, and the other for the forming plunger. The first of these is the smaller one, located at the right hand side of the machine. Its pistons are connected by links with two rocker shafts, one at the front and the other at the rear of the machine. These rocker shafts carry arms to which are pivoted connecting rods, attached to the blank holder. This mechanism forms a series of four toggle joints, one at each corner of the blank holder. The lever, controlling the valve of this small cylinder, enables the operator to elevate or lower the blank holder, and securely lock it on the stock at pleasure, independent of other movements of the machine. The blank holder has a vertical movement of 19 inches, and the pressure which it is possible to exert through it on the blank is estimated to be approximately 1,400 tons.

The main cylinder for operating the forming plunger is mounted on the yoke connecting the two side housings, at the top of the machine. It is 28 inches in diameter and gives a stroke of 50 inches. Its piston rod is attached to a steel cross head or ram weighing about 6,000 pounds, and this, with the male forming die which is attached to it, gives a falling weight

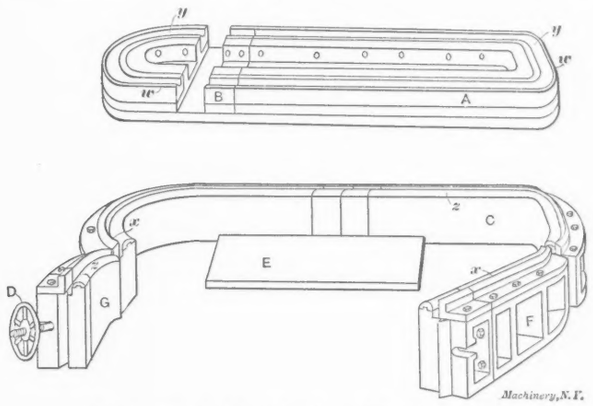


Fig. 3. Dies used for Trimming and Rolling the Rim.

of about 20,000 pounds. The base or anvil of the machine is made in three sections, the combined weight of which is about 90,000 pounds. The main arch and cylinder and the two housings or uprights are securely bolted together on the anvil, and reinforced by four large tie-rods passing through from top to bottom and shrunk in position.

The dies used for drawing the stock consist of a female die made adjustable for three sizes or lengths, and a forming punch for each die, which is keyed to the cross head or ram. Besides this there is a pressure plate for each size, securely bolted to the blank holder. The operator places a plain squared sheet or plate of steel, ⅛ inch thick, in position in the die, and brings the clamping mechanism into operation, forcing the blank holder and pressure plate down on the

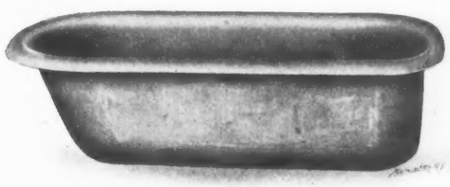


Fig. 4. The Tub after the Third and Last Operation.

sheet, where it remains at rest, automatically locked. Next, the larger cylinder is brought into operation, forcing the plunger onto the sheet and forming the stamping to a depth of about 12½ inches. This completes the first operation. It requires about 40 seconds to place the work in the machine, 40 seconds to do the work, and about the same length of time to remove the stamping. After being annealed and pickled to remove the scale, the work is again placed in position in the machine, which has been fitted meanwhile with the second operation dies. Here, in a similar manner, the forming of the stamping to a depth of 17½ inches is completed. The work now has the form shown in Fig. 2.

The stampings are then ready for the trimming process, where the flange is trimmed and the curved rim formed. Here two operations are completed at one stroke of the machine. This machine is similar in design to the one made by the same

firm and illustrated in the new tools column of the March, 1907, issue of MACHINERY. The machine is, however, considerably larger and heavier to fit it for this particular work. The dies used are illustrated in Fig. 3. The plunger, shown inverted at *A*, is provided with two filling pieces, one of which, *B*, is in place in the cut, while the space in which the other fits is shown alongside of it. These filling pieces allow the punch to be altered for different lengths of tubs, three sizes being made with this set of tools. The die is shown at *C*. This also has filling pieces on either side to adjust its length to that of the punch. The front side is hinged at either end, so that it may be opened up to facilitate the removal and insertion of the work.

The stamping, in the condition shown in Fig. 2, is placed in the die *C* in Fig. 3, which is thereupon closed and locked by hand-wheel *D*. Plunger *A* now descends. The outside cutting edge of the plunger at *w* strikes the blank all around, shearing it off against the cutting edge *x* in the die. The continued downward movement of *A* rounds the rim thus left between semi-circular groove *y* in the plunger, and the rounded top *z* of the die. On the upward stroke, the work adheres to the plunger and is carried up with it until it is released by a positively-operated knock-out, when it falls back into the die. Lower knock-out *E*, which has meantime been raised from the bed of the press, prevents it sticking in the lower die, and makes removal easy. The tub, finished, so far as the forming is concerned, is shown in Fig. 4.

The machines herein described are of unusual size, and represent quite an achievement in the way of heavy forming without recourse to the hydraulic press. A few figures will give some idea of the capacity and weight of the machine shown in Fig. 1. The width between the housings is 96 inches, the area of the bed is 96 inches right to left, by 60 inches front to back. The total height of the machine from the bottom of the bed to the top of the cylinder is 23 feet, and the net weight is 260,000 pounds.

EBERHARDT BROS. NO. 5 AUTOMATIC GEAR CUTTER.

The two halftones shown herewith illustrate an automatic gear cutting machine for spur gears, built by Eberhardt Bros. Machine Co., 66 Union Street, Newark, N. J. This machine, which is the largest of the line so far developed by this firm,

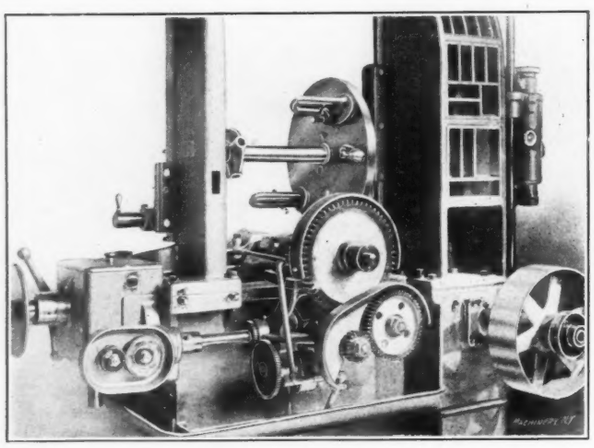


Fig. 1. Eberhardt Automatic Gear Cutter, Rear View.

is a heavy, strongly driven tool of simple construction, involving a number of features of unusual interest.

At full swing, a gear 60 inches in diameter and of a face width up to 16 inches can be handled, 2½ diametral pitch in steel, or 2 in cast iron. The unusual width of face provided for is allowed by the long cutter slide construction and the arrangement of the frame which allows the cutter to come up close to the column. The spindle bearing is in the center of the slide, and the thrust bearing of the feed screw is so located that it is always under tension, whether feeding or returning the slide. The slide is thus drawn and not pushed. Another new feature of the feed gearing is the provision for a change in the ratio obtained by a sliding gear moved by a handle. With any pair of gears in place two feeds can thus be obtained. The change is so arranged that one feed is suitable for the first cut and the other for the finishing cut, when using a finishing cutter and one or more roughing cutters in a gang. The feed changes are arranged in geometrical progression, giving from ¾ to 15 inches per minute. As the cutter speeds range from 20 to 128 revolutions per minute, the new feed arrangement allows the use of high speed cutters to advantage, inasmuch as fast feeds can be used, which it would be difficult to obtain in the usual manner.

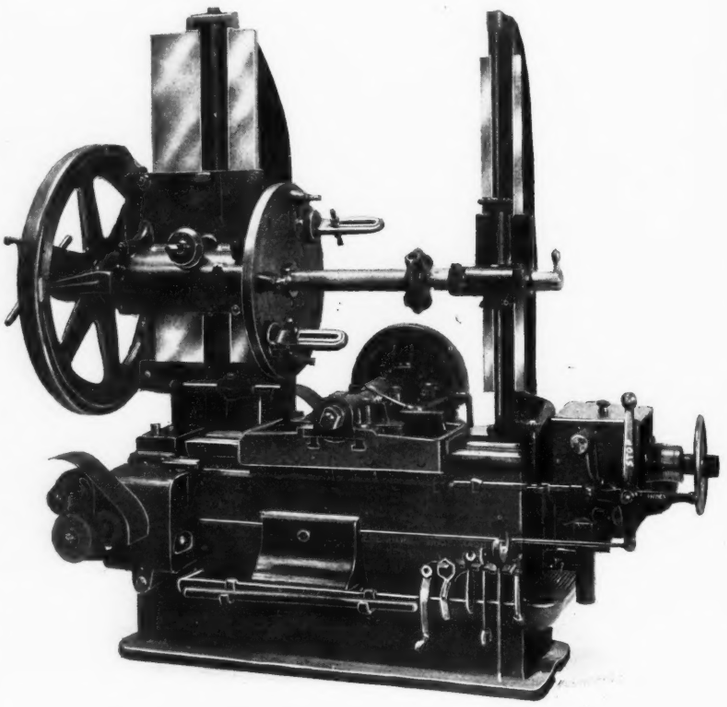


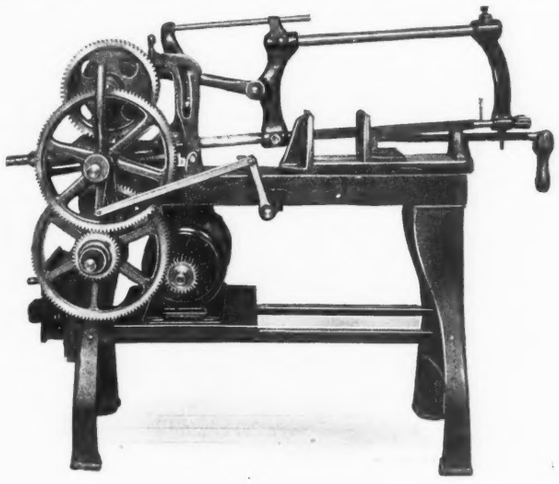
Fig. 2. Eberhardt Bros. No. 5 Automatic Gear Cutter for Spur Gears.

The index wheel is of large diameter, made in two sections. It is hobbed in place, and by successive settings and cuttings the wheel is made of the highest accuracy possible. The indexing mechanism is positive, employing a locking disk operated by a positive clutch. The disk makes one or more full turns and is locked in position at the end of each indexing without depending on the momentum. When the indexing is in progress, the feeding is automatically locked, so that the cutter slide cannot move until the division is completed. The feed is also interlocked with the indexing mechanism, so that it cannot index while the slide is feeding. The levers for engaging and disengaging the feed and for indexing by hand are placed on the operating side of the machine to facilitate the setting.

The cutter spindle is set in the center of the cutter slide bearing. It is made from a hammered tool steel forging, and is driven, as shown in Fig. 1, by spur gearing through change gears from the driving shaft. The spur gear gives the most efficient transmission of any form of gearing, and is especially advantageous for the high spindle speeds used with high speed steel cutters, where a worm would waste considerable power and tend to wear out. A good test of the drive and feed mechanism was shown in the cutting of teeth of three diametral pitch in 30 point carbon steel, 5 inches face, from the solid, using a roughing and finishing cutter side by side. The feed was 4½ inches per minute. These cutters were, of course, regular carbon steel cutters, and the feed and speed could have been increased had they been of high speed steel.

ROBERTSON NO. 3 MOTOR-DRIVEN HACK-SAW.

The Robertson Mfg. Co., of Buffalo, N. Y., makes a specialty of the manufacture of power hack-saws, which it furnishes in various styles and sizes to suit the needs of customers. The machine shown in the accompanying cut is motor driven, and has a positive geared connection between the armature

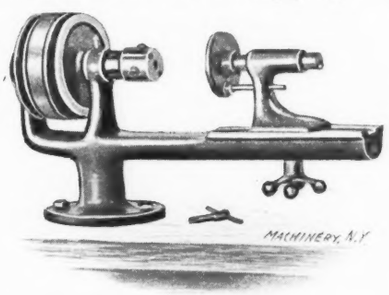


Robertson No. 3 Motor-driven Hack-saw.

shaft and the crankshaft. The motor is mounted on brackets supported on the legs at the rear end of the bed. The pinions are of fiber, bushed with metal. The motor is furnished for direct or alternating currents, and is ¼ horse-power in size. The machine shown has the builder's adjustable frame, which provides for using short blades on small work. The complete line of which this machine is a member, consists of eight sizes, with a maximum capacity of 4 x 4 for the smallest and 12 x 17 inches for the largest.

CHAMPION TAPPING MACHINE.

This tool is designed for tapping small holes in light work, either through or to depth. It has two friction pulleys, driven from the countershaft by open and cross belts so that they revolve in opposite directions. These spindles are mounted on self-oiling bronze bearings, independent of the spindle of the machine, which may thus be made light and left very sensitive. The work is held against a plate in the adjustable tail-stock, while the tap is held in a chuck in the end of the spindle. The spindle carries a friction, which may be made to engage with either of the two driving pulleys. The work,



Machine for Light Tapping, made by Blair Tool & Machine Works.

held against the plate on the tail-stock spindle, is brought up against the tap and fed in toward it lightly, a slight pressure giving the necessary power, through the friction, for driving the tap in the forward direction. At a predetermined depth the movement of the tail-stock spindle is arrested by an adjustable stop. As the tap continues to screw into the work, it is then drawn in toward it, thus releasing the forward driving friction, whereupon the tap comes to a standstill. The work is now dropped back, bringing the tap and spindle with it, and engaging the friction of the backing out pulley, thus screwing the tap out of the work. This arrangement makes a very quickly-operated machine and one in which the breakage of even the smallest taps is reduced to a minimum. Holes up to ¼ inch in diameter may be threaded. This machine is manufactured by the Blair Tool & Machine Works, 24, 25, 26 and 27 West Street, New York.

ADDITIONS TO THE BROWN & SHARPE LINE OF SMALL TOOLS.

The Brown & Sharpe Mfg. Co., Providence, R. I., has recently made a number of additions to its line of small tools for machinists and tool-makers. We describe herewith a number of the most interesting of these.

One of the new tools, a pocket scriber, is a neat and inexpensive instrument, intended for carrying in the pocket. For this purpose it is provided with a removable point, which is held in the handle by a 4-jawed chuck operated by the knurled nut at the lower end of the body. When not in use, this point is reversed so that there is no danger of piercing the clothing or injuring the operator, if it is carried carelessly. The scribing point is carefully tempered. The handle is knurled for a finger grip and is provided with a hexagonal head to prevent rolling when it is laid on the bench. The tool is about 3½ inches long when reversed for carrying.

In Fig. 1 is shown an attachment intended for use with the maker's well-known automatic center punch. As shown, the attachment is screwed onto the center punch in place of the removable point. When so arranged, it will be found useful in quickly and accurately laying out holes in circles. The fine adjustment of the locating point is obtained by the screw at the end, and the quick adjustment, by pulling out the knob at the top of the post. The point is held by a knurled check nut, and it can be adjusted to suit varying lengths.

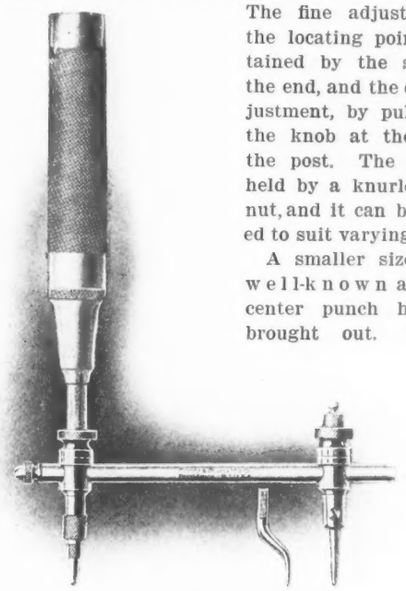


Fig. 1. Spacing Attachment for Automatic Center Punch.

A smaller size of the well-known automatic center punch has been brought out. This is made to meet the demand for a small, light tool, suitable for the delicate work required in tool-making. It operates in the usual manner, a downward pressure on the head releasing the striking block and making the impression. The striking mechanism is adjusted to give a quick and uniform punch mark. The tool is constructed of steel throughout, hardened and tempered wherever subject to wear, and nicely finished. It is 4⅛ inches long over all, and ⅜ inch in diameter.

A novel combination caliper and divider set is made, comprising a pair of legs carrying chucks at the lower ends, in which may be inserted and held auxiliary legs of various shapes. The tool may thus be used for dividers, outside or inside calipers, or a combination of outside and inside. A pencil can be substituted for one of the legs if desired, thus making the tool useful as a compass. The instrument is of steel throughout, carefully finished, with sharp corners eliminated. When used as a divider, it will describe a circle 21½ inches in diameter.

A set of steel rules with a holder provided for them, as shown in Fig. 2, will be found convenient where ordinary rules cannot be used, as in measuring in grooves, recesses, keyways, etc., or other inaccessible places in general tool and die work. Five sizes of rules or scales are provided, ¼, ⅜, ½, ¾, and 1 inch respectively. These are of tempered

steel, graduated on both sides in either of the two following styles: 32ds on one side and 64ths on the other, or 50ths on one side and 100ths on the other. The holder carries a split chuck in its lower end, adjusted by the knurled nut at the top of the barrel. The rules can be set in it at various angles to suit the case in hand. The barrel of the holder is knurled for a finger grip.

The Brown & Sharpe Mfg. Co. has also put up a micrometer caliper set, carrying instruments of three sizes, giving a range of from 0 to 3 inches in English measurement, or from 0 to 75 millimeters in the metric style. The 1- and 2-inch instruments are of standard type, while the 3-inch caliper has

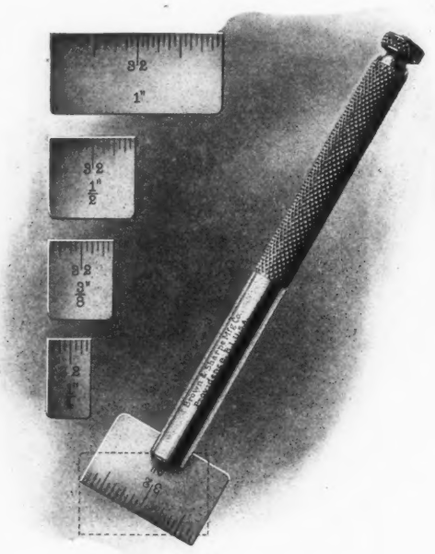


Fig. 2. Set of Short Steel Rules with Holder.

a frame of I-beam section which combines lightness and rigidity. They are furnished either with or without the ratchet stop. A standard reference disk is provided for adjusting the 2-inch caliper, and a standard end measuring rod for the 3-inch size. The whole is neatly arranged in a substantial case, lined with velvet and covered with leather.

ELECTRIC FAN FOR SINGLE PHASE CURRENT.

The Western Electric Co., of New York and Chicago, has devised a fan motor for use on singie phase alternate circuits, which does away with most of the difficulties usually experienced when dealing with a current of this kind. The induction motor has generally been used for this service. It has one great drawback, however, and that is its uncertainty in starting immediately after the current has been turned on. The ordinary induction motor will not run properly until it gets up to the proper speed, the starting torque being so small that several spasmodic revolutions of the armature are required before it gets down to work. The new Western Electric fan motor is a commutating machine. It starts positively when the current is turned on, because it does not act on the induction principle, but in the same way as the regular series direct current fan motor. Other mechanical features of the device are: The improved bracket or standard which allows it to be used as a desk or bracket fan at will; the fact that the working parts are completely enclosed from injury by dust or dirt; and the improved design of the blades, which are built to follow specially designed lines, furnishing a maximum breeze with a minimum current consumption.

EDGE TOOL GRINDER WITH REVOLVING OIL STONES.

The accompanying halftone shows a novel machine designed for quickly sharpening edge tools of various kinds, superseding the grind stone and the oil stone as well, doing the work of both in a quicker and more satisfactory manner. The machine, as shown, is mounted on a pedestal at a convenient height, and carries a horizontal spindle with a wheel at each end, enclosed within a casing forming a part of the frame of the machine. The spindle is driven by spiral gears from a shaft having driving pulleys at the rear, out of the way of the operator, who is thus free to stand at the front or at either end of the tool, as may best suit his convenience. Of the two wheels on the main spindle, one is comparatively coarse and free cutting. This is used for the roughing cut. The second stone is finer, with the nature of an oil stone, and no final treatment on a hand stone is required.

The wheels may be run in either of two ways. A bath of oil (kerosene answers the purpose very nicely) may be used in the casing, to prevent the tool from heating, and keep the surface of the stones clean and free from glazing. In this case the wheels should revolve at the rate of about 340 revolutions per minute, which is not fast enough to throw the liquid. An alternative method is to speed the wheels up to about 700 revolutions per minute, saturating them with kerosene before starting. The wheels readily absorb the oil, and when not in motion appear to be dry, but as soon as they start to revolve, the oil is brought to the surface by centrifugal force. Here the adhesion of the oil to the stone overcomes the centrifugal force and holds the oil right on the surface of the wheels. After the stones have been once saturated, it is only necessary to occasionally put on a few drops of oil. In this way the same results are obtained as if they were run in a continuous bath. This scheme is rather to be preferred, as the work is done almost twice as fast.

The wheels are enclosed in a casing, which is provided with two lids or covers, serving to protect the wheels from accident when not in use, and also to keep out the dust with which the shop atmosphere is usually charged. When open, the lids act as oil trays to catch any oil which might run along

Revolving Oil Stone Tool Grinder.

the tool and drop off. On being closed the lids return the oil to the receptacle in the casing.

There is a small supplementary spindle driven by a round belt from the driving shaft, to which may be fastened either of two round faced grinding wheels, providing for sharpening gouges and molding bits. This machine is built by the Mummert, Wolf & Dixon Co., of Hanover, Pa.

IMPROVED NO. 21-2 BATH UNIVERSAL GRINDER.

The two halftones shown herewith illustrate an improved form of the grinder, built by the Bath Grinder Co. of Fitchburg, Mass. The changes which have been made have greatly increased the efficiency of the tool for all classes of work for which it was intended. This machine was described in the March, 1905, issue of MACHINERY. It will be noted that a marked improvement has been made in the spindle head over the old pattern. It is much heavier, and is fitted with taper split boxes whose large ends are at the ends of the head, thus giving rigidity to the spindle close up to the wheels. Surrounding the spindle box at the right hand of the spindle head is a projecting square flange, to which the wheel hood is

clamped. The clamp screw for binding it is in a straight line under the spindle, making the attachment useful as a safeguard in case of breakage of the wheel. The spindle head is elevated by the vertical hand-wheel on top of the machine, a graduated dial giving the movement to within 0.001 inch. The spindle is driven by a horizontal belt, and any belt tension desired can be obtained by the adjustment nuts shown on the rod at each side of the cone frame in Fig. 2.

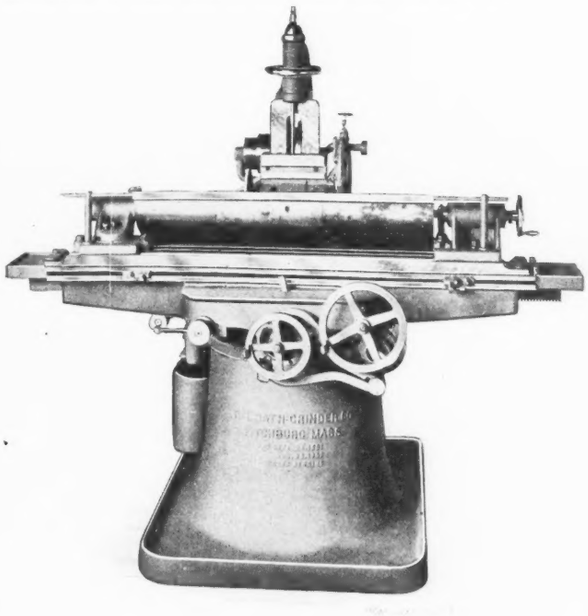


Fig. 1. Improved Bath Universal Grinder.

An improvement which adds greatly to the rigidity of the machine is the lengthening of the bearings of the table slide. The reversing of the table and its starting and stopping, are controlled by the same lever, shown at the left-hand side of the apron opposite the two hand-wheels. By this construction, in all kinds of grinding it requires only one hand of the

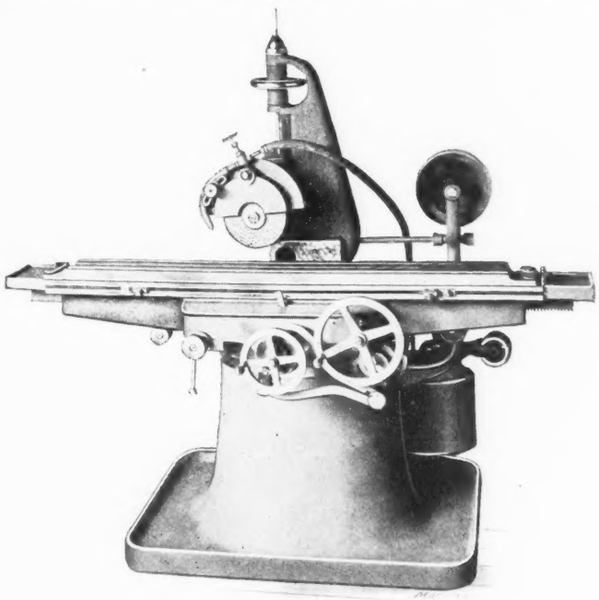


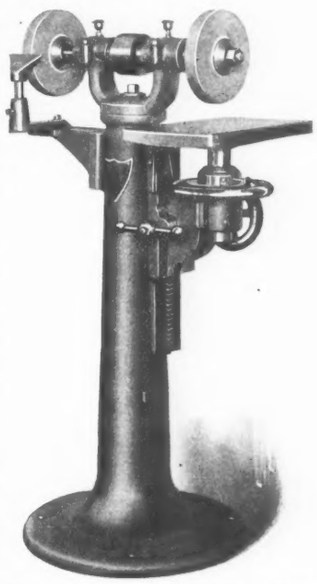
Fig. 2. The Bath Grinder arranged for Surface Grinding.

operator to reverse or stop the machine, leaving the other hand free. The table may be shifted about as shown in Fig. 2 to adapt the machine to surface grinding. An outboard support may be used if desired, in surface grinding and similar operations. It is attached to the face of the head by two bolts, being located by a tongue entering the groove shown in Fig. 1. On the projecting end of the arm is a phosphor bronze bearing, the lower end of which is adjustable to suit the spindle. This assures absolute rigidity and prevents spring in the spindle when taking heavy surface cuts. Mounted on the end of the arm is a wheel hood arranged for holding the water spout. In this case the water spout is used on either wheel hood as shown.

Suitable attachments have been provided to adapt the machine to a wide range of work, such as cylindrical and internal grinding, cutter and reamer grinding, etc. These include a rigid support for the internal grinding spindle; suitable holders, stops, etc., for small tools, vise, live spindle and chuck for head-stock; and an assortment of back rests, wheels, wrenches, etc. The capacity of the machine is as follows: from the center of the spindle to the top of the swivel plate is 11½ inches; it takes 36 inches between centers, and may be furnished to swing either 9½ or 14 inches. In surface grinding, the wheel covers an area of 36 inches by 8 inches. Complete with all attachments, the machine weighs 3,500 pounds.

MICROMETER FEED SURFACE GRINDER.

The La Salle Machine & Tool Co. of La Salle, Ill., has recently begun the manufacture of a line of machine tools. The first tool of this line is shown in the accompanying halftone. It is a surface grinder, intended for toolroom and general shop use, for fitting keys, sharpening punches and dies, and for the innumerable small jobs always coming up to be filed or ground.



Surface Grinder with Micrometer Adjustment for the Table.

Especial attention is called to the design of the work table. It has a rapid adjustment of the knee on the column by means of a rack and pinion operated by the hand-wheel at the right, and clamped by the hand nut at the left. The table is carried by a stiff post which may be adjusted vertically in the knee, and is prevented from turning horizontally by a key. A hand-wheel, as shown, encircles this post and provides a fine adjustment of the work table for depth of cut. This hand-wheel carries a dial, graduated to read in thousandths of an inch. The division marks being 3-16 inch apart, finer adjustments may readily be estimated. A dust ring is provided, which preserves the elevating screw from injury due to the accumulation of grit and emery dust.

The table is 8 x 14 inches, and has a vertical travel of 12 inches on the guides and ¾ inch by the micrometer wheel. The spindle runs in cast iron bearings at 3,000 revolutions per minute. All the bearings are adjustable for wear. A vise is furnished for clamping pieces too small or irregular to be slid on the table. The net weight of the machine is 300 pounds.

BURR COLD SAW.

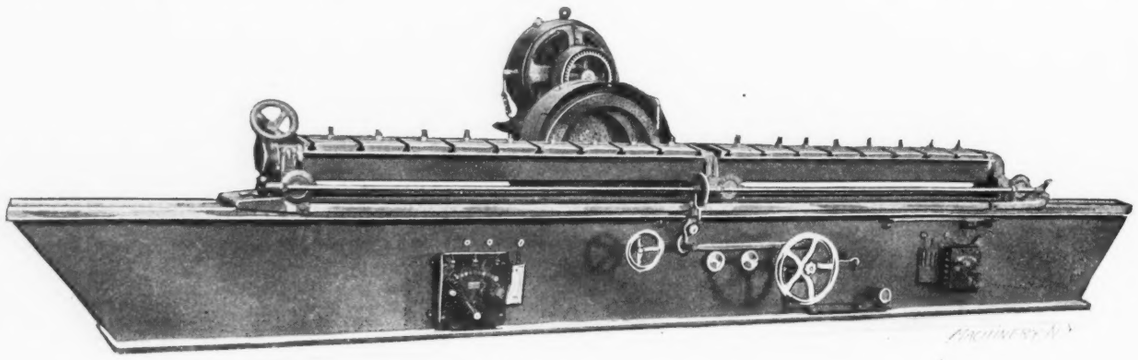
John T. Burr & Sons, 34 South 6th St., Brooklyn, N. Y., have brought out a cold saw which is intended to take the place of the usual power hack saw. For this purpose it has been given some of the special features of that machine without sacrificing the good points inherent in the rotary type of blade, which is naturally a much more rapid and accurate instrument.

The blade is driven by steel spur gearing and a worm and worm gearing, a ball thrust being provided for the worm. The feed is by gravity, a weight and lever being used. This keeps the saw up to its work at all times, even though the blade may be considerably out of round. The saw used is 10

inches in diameter by 3-32 inch thick, and it will cut off blanks square within 0.005 inch in the range of the machine. The saw blades should last for months of steady cutting. They can be ground when necessary on a bench grinder furnished with the machine. A stock stop is provided so that any number of pieces may be cut off to the same length. The holding device provided allows the clamping of rounds, flats, squares and other shapes not over 3 x 3½ inches in extreme dimensions.

TWELVE-FOOT MOTOR-DRIVEN CUP-WHEEL KNIFE GRINDER.

The unusually heavy knife grinder shown in the illustration below, is one of the latest products of the Bridgeport Safety Emery Wheel Co., Inc., of Bridgeport, Conn. The whole machine is strongly constructed, both the bed and the emery wheel bracket being made in solid cabinet form. The cup emery wheel is 24 inches in diameter and 8 inches deep, with a 2-inch rim. With a wheel of such large diameter there is more cutting surface than usual, so that it will not wear out as fast as a smaller wheel. With the cup form, the periphery is always driven at the same surface speed, irrespective of whether the wheel is new or nearly worn out. It is usually set square with the work so as to give a flat surface to it, but when desired it may be swiveled to a slight angle to give a concave shape to the edge of the blade being ground. This swiveling is facilitated by the fact that the wheel is motor driven, thus avoiding the trouble that would otherwise arise from twisting or slacking the driving belt. The motor, which is 7½ horse-power, is geared to the wheel spindle with a cut gear and pinion, giving the wheel a speed of about 450 revolutions per minute. As the wheel wears down, it may be moved in towards the work by the small hand-wheel seen at the front of the bed.



Knife Grinder of 12-foot Capacity, built by The Bridgeport Safety Emery Wheel Company.

The knife blade being ground is clamped to the heavy square column or knife bar shown on the table. This knife bar is very rigid, so that long knives can be clamped down to it firmly, taking out the wind and spring caused by tempering. In addition to the usual end supports, there is an extra central support as shown. One end of the bar carries a graduated dial, so the work can be set and ground to the same angle each time. The knife bar is adjusted for the angle by means of a worm, worm-wheel and large hand-wheel. The knife bar is fed forward to the wheel automatically by bevel gears and cross feed screws at each of the three supports as shown, the feed being automatically operated by the reversing mechanism through an adjustable dog and ratchet, which can be arranged to give as fine a feed as 1/4,000 of an inch. It will stop feeding and grinding at any point, so that when properly adjusted and set in motion no attendance is required.

The carriage is driven back and forth by a 5-horse-power motor, its mechanism being entirely disconnected from that of the spindle. This movement is strongly back geared, and is friction driven through an all-geared reversing mechanism, operated by adjustable dogs attached to the front of the carriage. By this arrangement the motor itself runs continuously in the same direction. It will be noted that the bed of the machine is very long, so there is no tendency for the bar to be sprung and its accuracy impaired by long over-hang at the end of its travel.

The weight of the machine with the length of traverse shown, 12 feet, is 9,000 pounds. It is made in lengths up to and including 15 feet.

BURKE DOUBLE SPINDLE MILLING MACHINE.

The Burke Machinery Co., of Cleveland, Ohio, is building a novel milling machine designed for typewriter parts, and similar work. The machine is a hand miller, of interesting construction. The novel feature is the use of two spindle heads, which may be adjusted to give a distance of from 4 inches to 6½ inches between the centers of the spindles. By this means, two ends of a piece can be milled at the same time, thus saving labor and insuring accuracy and alignment. The longitudinal feed of the table is 6 inches, the cross feed 2½ inches, and the vertical motion of the knee 5½ inches. The working surface of the table is 12 x 4 inches. The machine and countershaft together weigh about 400 pounds.

NATIONAL ASSOCIATION OF MANUFACTURERS' TWELFTH ANNUAL CONVENTION.

The National Association of Manufacturers held its twelfth annual convention and banquet May 20, 21 and 22 at the Waldorf-Astoria Hotel in New York City. The credentials of over 500 members were received, and the convention was perhaps the most important of any held in the history of the association. Mr. James W. Van Cleave, of St. Louis, Mo., was re-elected president. Among the speakers at the business sessions were Hon. Charles A. Prouty, of the Interstate Commerce Commission, "Further Railroad Legislation"; Mr. Charles M. Pepper, special agent of the Department of Commerce and Labor, "Foreign Trade: How to Get It and Keep it"; Dr. Charles P. Neill, Commissioner of Labor, "Certain Aspects of the Child Labor Problem"; Mr. Arthur D. Dean, "Trade Schools: The Manufacturer of the Pedagogue Sort." Captain Henry A. Castle stated in his address, "Needed Postal Reform," that one-cent postage was possible if present wastes were prevented. A bronze plate bearing a testimonial inscription was presented to Mr. David M. Parry in recognition of his work for the association during the four years that he was its president. At the banquet in the evening of May 22, at which about 500 were entertained, the guest of honor was Hon. Oscar S. Straus, secretary of the Department of Commerce and Labor. Mr. Straus spoke with vigor for fairness in the dealings of labor and capital and for unbiased treatment of each alike. He said that immigration was largely responsible for our great prosperity and the variety of our manufacturing industries. Rear Admiral Charles D. Sigsbee, of the navy; Major-General J. Franklin Bell, of the Army, and others, spoke. The sentiment of the majority of the members of the association in regard to the present tariff is in favor of revision and reform. A resolution was adopted for the establishment of a non-partisan tariff commission similar to the present Interstate Commerce Commission. A most radical proposition was the request by President J. W. Van Cleave for a fund of $500,000 per year for three years to be used for the establishment of the "open shop," combating strikes and "labor" legislation, and meeting labor troubles in general.

INDUSTRIAL NOTES FROM EUROPE.

BRITISH TRADE ENTERPRISES.

Trade generally remains exceedingly brisk, though several matters in connection with wages in cotton trade and engineering circles cause considerable anxiety. Engineers have received a 2½ per cent advance in Manchester, but have been refused in Birmingham. An attempt was made to obtain some relaxation of the agreement entered into by the Engineering Employers' Federation and the leading engineering trades unions in 1897, but, though the wording is now less peremptory in tone, the effect is still the same—that the employers exercise the right to place any man on any machine at any wages mutually agreed on. The continued prosperity of the cotton trade, which favorably affects many other industries, is causing demands for increased wages from all classes of work people. Federations of all branches of the trade are being gradually forced on both employers and workpeople, with the result that any struggle would be of such a comprehensive character that every possible conciliatory influence will be brought to bear to prevent such a disaster. Considerable distress is being experienced at Woolwich in consequence of discharges of workmen, on a large scale, from the arsenal. This course is more or less bound to follow the fact that military requirements are now on a peace footing.

A number of improvements are being carried out at Liverpool with a view to keeping the port suitably equipped for dealing with modern shipping. The Mersey channel is being deepened 10 feet, so that it will have a depth of 37 feet at low water. The increased facilities at Southampton are no doubt partially responsible for the increased activity shown at Liverpool. Shipbuilding during the first quarter of the year was not quite so brisk as in the corresponding period of 1906, but the Clyde record was 63 ships, totaling 121,000 tons, which included a good foreign demand. The Elswick works on April 13 launched the *Invincible*, cruiser, 530 feet long, or 50 feet longer than any other cruiser, 78 feet 6 inches broad and 17,250 tons displacement. She is fitted with Parsons turbines of 40,000-horse-power, water-tube boilers, and will steam 25 knots. The vessel is to be completed and delivered in twelve months from ordering. Several similar vessels—which are the *Dreadnoughts* of the cruiser class—are being built on the Clyde. Another interesting naval vessel just launched at Sunderland by Sir James Laing & Son, Ltd., is the *Cyclops*, which is intended to accompany a fleet as a comprehensive naval repairing shop. She is 460 feet long by 55 feet broad and 45 feet deep. The lower deck is fitted up as a foundry, the other decks providing all facilities for boiler making, engine fitting and machining, coppersmiths, carpenter and electrical work, etc. An ice-making plant will be installed, together with a water-distilling plant, sufficient for the fleet. A wireless telegraphy outfit is included, and the picked crew will be about 300 strong.

Considerable additions and improvements to plants generally have been taking place in British iron and steel and shipbuilding centers during the last few years. In the smelting industries advantage has been taken of American ideas, modified to suit local conditions, and the benefit experienced is already well marked. In shipbuilding the developments are mostly on British lines, though some heavy lifting tackles have been adopted from German sources. Armstrong, Whitworth & Co., Elswick and Manchester, and Beardmores, Glasgow, have been very prominent in the way of extensions in shipbuilding and armor plate plants. Touching on shipbuilding, most interesting papers have recently been presented before, and discussed by, the Institution primarily interested in the topic. The paper by Mr. Luke, detailing the plating methods employed while building the *Lusitania*, draws attention to the remarkable advances in the rolling of steel plates, since iron and steel vessels were first built. In the case of the *Lusitania*, the shortest plates were 32 feet long, and the width only limited by the gaps of the hydraulic riveters used. The *Engineer* suggests that the building of future vessels may call for plates 100 feet long and 10 to 12 feet wide *produced in the shipyard itself*. The riveting on the above ship was equal to the best boiler practice, punching hardly being resorted to. All drilling was done in place, and the plates removed, the drillings cleared away, and all holes countersunk to remove burrs. As showing the multiplicity of auxiliary equipment on board modern liners, it may be mentioned that the Chadburn Ship Telegraph Works, Liverpool, received a contract for 500 ship's telegraphs for installation on the two new Cunarders.

Overhead tracks with switches, turntables, etc., for use in workshops, etc., have received a good measure of appreciation during the last few years, this system proving very elastic and adaptable in cases where traveling cranes are inadmissible. Nettlefolds, Ltd., are exploiting the Coburn trolley track, while Herbert, Morris & Bastert, Ltd., Loughborough, and Vaughans, Ltd., Manchester, are other typical exponents of the idea. The hand lifting blocks in connection with the tracks have come in for much attention, and several very meritorious spur-geared blocks are coming into use which show a distinctly improved mechanical efficiency over many other forms of lifting tackle. In fact, the inexperienced buyer is likely to be bewildered by the multiplicity of good things offered him, and there is little doubt that the treatment of the whole subject has recently been raised to a higher level. Not long ago, Great Britain was an almost negligible quantity as regards the building of automobiles—as now understood—but the last year or two has witnessed a decided change in this respect, as may be seen from the fact that for the first three months of this year the value of the exports in this line was not less than $552,970. There are signs that the needs of would-be purchasers, whose means are only moderate, are to receive some approach to adequate attention.

Several tool builders appear disposed to question the superiority of the vertical boring and turning mill over a well designed lathe, for dealing with such jobs as gas engine flywheels. Broadbent, of Sowerly Bridge, has built, at moderate cost, some very successful lathes for this purpose. Shanks & Co., Johnstone, build a quadruple-geared slide break lathe for somewhat similar work. This lathe has a self-contained gap frame to swing work of large diameter and great width. The head-stocks are 30 inches high and the bed 4 feet wide, and jobs 14 feet diameter and 7 feet 6 inches wide may be swung in the gap. It may be remembered that an interesting tool for work of this class by J. Butler & Co., Halifax, was described in the issue for April. Grinding machines—of precision—were, years ago, considered almost sacrosanct as regards their manufacture, but quite a few makers on this side are tackling the subject with very encouraging results, and the experience thus gained is distinctly to the good of the British machine-tool trade. Off-hand in this line we may mention J. J. Guest, Birmingham; G. Birch, Salford; The Churchill Machine Tool Co., Ltd., Manchester; The Newall Engineering Co., Ltd., Warrington, etc., and disk grinders embodying all degrees of efficiency find no lack of sponsors. Pneumatic tools find constantly increasing application. For blacksmith work the power hammers built by B. & S. Massey, Manchester, are very successfully handling much of the work formerly dealt with by steam hammers. They are driven by belt or electric motor, two cylinders being used, in one of which the air is compressed, and in the other the tup-holding rod and piston work in the same manner as the steam hammer. These hammers are made in sizes from 112 pounds to over 2,000 pounds, the sizes being designated by the weight of the tup used. This class of hammer lends itself admirably to the simplification of workshop lay-out, the problem of condensation from long lengths of steam pipe, and annoyance, due to water dripping from the piston rod stuffing-box onto the work, being eliminated. Their general appearance and method of working is much the same as that of the steam hammer, and workmen have no trouble in adapting themselves to their use. The manufacture of pneumatic chipping and riveting hammers, drills, etc., is growing in this country, the latest concern to enter this field of production being Smith & Coventry, Ltd., Manchester, who are making excellent records with their "Stox" hammers, which use two pressures of air—100 pounds for the blow, and 15 pounds for the return stroke. A special merit of this system is the absence of vibration, a feature feelingly appreciated by operatives handling them.

Manchester, Eng., April 27, 1907. JAMES VOSE.

THE MACHINE TOOL BUILDERS' CONVENTION.

The convention of the National Machine Tool Builders' Association was opened at Old Point Comfort, Virginia, May 14, 1907. The address delivered by President Woodward dwelt on the growth of the association and its increasing influence. Appropriate reference was also made to the four prominent members who have died since the last general meeting. These are H. J. Hendey, of the Hendey Machine Co.; Edward P. Bullard, of the Bullard Machine Tool Co.; Joseph Flather, of Flather & Co. Inc.; and Harry C. Hoefinghoff, of the Bickford Drill & Tool Co.

A report was received from the Committee on Uniform Cost Accounting. This was carefully prepared, going very minutely into the fundamental principles of cost accounting. It was accompanied by an elaborate chart showing the elements entering into the cost of production on machine tools. Discussions of this report were contributed by President Woodward, C. H. Norton, and E. Payson Bullard. President Woodward spoke of the value of an accurate knowledge of costs in preventing unintelligent competition in a falling market. Mr. Norton spoke of the necessity for checking the cost department figures by the manufacturing department, as absurd errors are often made, which it is impossible for the clerical force to recognize and rectify. Mr. Bullard explained a system in vogue in the Bullard Machine Tool Co.'s plant which did away in a large measure with the difficulty just mentioned.

Other matters engaging the attention of the members at succeeding meetings were the responsibility of foundrymen, the claims of buyers, standardization of catalogues, and the advisability of exhibiting at expositions. It was the general impression of the machine tool builders that the 6 x 9-inch size of catalogue is the most suitable for general use. In the matter of expositions, it also seemed to be fairly well agreed upon that there is little profit in doing anything with those held in this country, where the thing has been rather over done. Exhibiting at foreign expositions, however, has apparently been profitable to American manufacturers.

E. Payson Bullard, of the Bullard Machine Tool Co., Bridgeport, Conn., submitted his report on the apprenticeship question. This was well received. It advised, among other things, the adoption of a uniform system of agreement between employers and the parents or guardians of the apprentices, and the retention of a certain amount of the apprentice's wages by the employer as a surety of good conduct. It also suggested the adoption of a diploma signed by the officers of the National Machine Tool Builders' Association.

The Henry & Wright Mfg. Co., of Hartford, Conn., and the Kern Machine Tool Co., of Cincinnati, Ohio, were made members of the association.

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SPRING MEETING OF A. S. M. E.

The spring meeting of the American Society of Mechanical Engineers was held in Indianapolis, Ind., May 20-31, the headquarters being the Claypool Hotel. Following is the program of papers presented:

Report of the Committee on Standard Proportions for Machine Screws.

Preliminary Report of the Committee on Refrigerating Machines.

Collapsing Pressures of Lap-Welded Steel Tubes. R. T. Stewart.

The Balancing of Pumping Engines. A. F. Nagle.

The Economy of the Long Kiln. E. C. Soper.

Ball Bearings. Henry Hess.

Air Cooling of Automobile Engines. John Wilkinson.

Materials for Automobiles. Elwood Haynes.

Special Auto Steel. T. J. Fay.

Railway Motor Car. B. D. Gray.

The Specific Heat of Superheated Steam. A. R. Dodge.

The Flow of Superheated Steam in Pipes. E. H. Foster.

Furnace and Superheat Relations. R. P. Bolton.

The Determination of Entropy Lines for Superheated Steam. A. M. Greene.

The Heating of Storehouses. H. O. Lacount.

Performance of Cole Superheaters. W. F. M. Goss.

Experiences with Superheated Steam. G. H. Barrus.

Superheated Steam in an Injector. S. L. Kneass.

Use of Superheated Steam on Locomotives in America. H. H. Vaughan.

Analysis of Locomotive Tests. S. A. Reeve.

Materials for the Control of Superheated Steam. M. W. Kellogg.

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WHITE STAR STEAMER ADRIATIC.

The newest and biggest liner, the *Adriatic* of the White Star Line, reached her pier at New York, Thursday, May 16, 1907. She is 725 feet 9 inches long over all, 75 feet 6 inches beam, with a hull about 50 feet deep. Her gross tonnage is 25,000 tons. There are accommodations for 3,000 first-class, second-class and steerage passengers. The boat has twelve water-tight compartments and nine steel decks. The double bottom extends through the whole length of the hull. The first- and second-class compartments are finely equipped, and a number of novelties have been introduced. Among them are a dark room for the amateur photographer and a Turkish bath attached to the gymnasium. The *Adriatic* is provided with submarine signalling apparatus of the submerged bell and telephone type, by means of which the officers of the vessel can be made aware in foggy weather of their proximity to similarly fitted ships and shore stations.

* * *

OBITUARY.

William J. Johnston, founder of the *Electrical World*, and one time publisher of the *Engineering and Mining Journal*, died April 28 at his home in New York. At the time of his death he was publisher of the *American Exporter*. Mr. Johnston was born in Ireland in 1853, and his first occupation was that of a telegraph operator. He published the first periodical in the United States devoted to things electrical.

WILLIAM H. DERBYSHIRE.

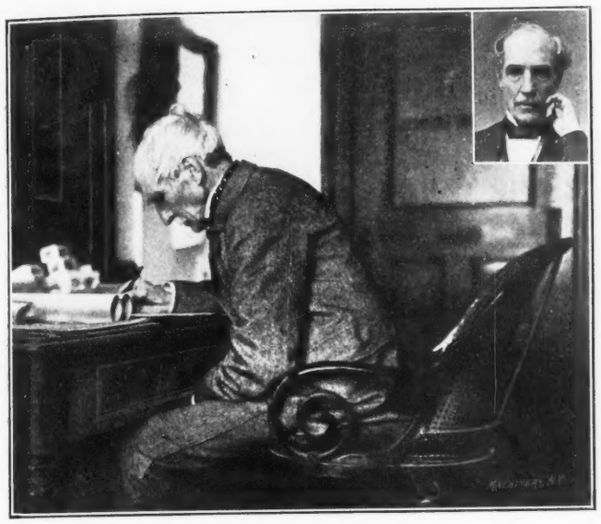
William H. Derbyshire, president of the Chambersburg Engineering Co., Chambersburg, Pa., died April 13. He was born in Canton, Ill., March, 1859. After graduating from the Polytechnic College of Pennsylvania in June, 1877, he went with the John Roach & Son Shipbuilding and Engine Works at Chester, Pa., where he remained until August, 1879, going from the Roach works to the machine tool works of Mr. Frederick B. Miles in Philadelphia. When the machine tool works and Wm. B. Bement & Sons were consolidated as the firm of Bement, Miles & Co., in 1885, Mr. Derbyshire became superintendent of the new concern, remaining in this position until November, 1897, when he formed the Chambersburg Engineering Co.

Mr. Derbyshire was a man of exceptional executive ability and engineering talent. He was an authority on smith shop and boiler shop equipment, and after the organization of the Chambersburg Engineering Co. he gave his entire time and attention to this class of machinery. He had taken out many patents on hydraulic equipment. One of them best known to the trade is his system of quick-acting hydraulic riveters and presses. The steam hammer was also the subject of numerous improvements at his hands, and steam drop hammers as well. Under his management the Chambersburg Engineering Co. has grown from a very small plant to its present extensive dimensions, the works now including a large machine shop, iron foundry, an open-hearth steel casting foundry, the total number of men at the present time employed being over 400. Although Mr. Derbyshire's death is a severe loss to the company, the organization is such that the work that he planned will be carried henceforward without interruption.

CHARLES HAYNES HASWELL.

Charles Haynes Haswell died at his home in New York May 12, 1907, of shock resulting from injuries received in a fall upon his dining-room floor, which dislocated his shoulder. Mr. Haswell, at the time of his death, was doubtless the oldest engineer in the world and was widely known as the "dean of engineers." He was born May 22, 1809, in New York, and, therefore, had nearly reached the great age of 98 years. Not-

withstanding his years, he was in good health, and was engaged in important engineering work for New York City on Riker's Island. Mr. Haswell received a classical education in the schools of New York and entered the engineering profession at the age of 19. In 1829 he was employed by the boiler works of James P. Allaire, a famous ironmaster of that period, and in 1836 became a naval engineer in the employ of the United States government. He rose to the rank of chief engineer, and in 1845 was made engineer-in-chief, which position he held until 1851. During this period he designed all of the machinery for ten ships and introduced numerous mechanical improvements. He is said to have been the first to use zinc in marine boilers to prevent corrosion. He is also



Charles Haynes Haswell.

credited with being the designer and builder of the first steam launch, called the *Sweetheart*. On retiring from the navy Mr. Haswell engaged in engineering practice in New York and for forty-two years was surveyor of steam vessels for marine underwriters of New York, Boston and Philadelphia. He retired from this post in 1893 and was since engaged in consulting work, of which municipal work for New York claimed a large share of his time. Although a civil engineer by profession he was known to most of our readers best as the author of Haswell's Mechanics' and Engineers' Pocketbook, first published in 1843 in a small volume of 284 pages, and which has just gone into its 72d edition. Harper & Bros., the publishers, state that the total number of copies printed and sold is over 146,000. This work, originally compiled when the profession of the mechanical engineer as such was almost unknown, contained much matter that is now considered outside its province, but, notwithstanding, it was and is a most valuable compendium of engineering knowledge and is highly regarded by thousands who refer to its convenient mathematical tables and other useful data. The accompanying cut shows Mr. Haswell working at his desk at his regular occupation, the photograph having been taken only a few months ago. The full-face portrait in the corner of the cut was taken several years before his death.

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PERSONAL.

Miss C. M. Hawkins, graduate of the Pratt Institute Library School has been appointed librarian of the Stevens Institute of Technology. An important feature of this library is the section devoted to patent literature containing files of the Patent Office Gazette and patent specifications. This section of the library has been liberally supported by Prof. W. H. Bristol.

W. H. Booth, London, England, a well-known consulting engineer and writer on technical subjects, is on a business trip to America in the interests of the American patents on the Collier sectional rubber tire, the Renard road train, and the Reavell air compressor. If satisfactory business connections are made, Mr. Booth may make the United States his place of residence indefinitely. He is in position to dispose of foreign patents for American inventors, especially in Great Britain and France, and to assist in the advantageous location of manufacturing rights in Great Britain.

Dr. William H. Tolman, director of the American Museum of Safety Devices, who has been appointed Commissioner General of the International Paper and Publicity Exposition to be held this year in Paris, will sail early in June. While abroad, he will visit the great European museums of safety devices and industrial hygiene, to gain information concerning their accessions during the last year, and to acquire material for the American Museum of Safety Devices, to be opened in New York in the new 39th Street Building early in the autumn. Dr. Tolman will represent the Museum at the International Congress of Associations for Preventing Accidents, to be held this year in Rome, and also at the International Housing Congress to be held in London during August.

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FRESH FROM THE PRESS.

TESTS OF REINFORCED CONCRETE BEAMS. By Ernest A. Moritz. 75 pages, 6 x 9 inches. Illustrated with numerous cuts and diagrams. Published by the University of Wisconsin, Madison, Wis. Price, 30 cents.

IRON AGE DIRECTORY. 331 pages, 4½ x 6½ inches. Published by the David Williams Co., New York. Price 25 cents.

This issue of the very convenient *Iron Age* Directory is of the eleventh annual edition. It is a classified index of all the concerns whose advertisements have appeared in the *Iron Age* during the preceding year..

TABLE OF VOLUMES THROUGH AIR-WAYS. By C. H. Kuderer. Published by C. E. Meyer, Allegheny, Pa. Price, 25 cents.

This table is printed on cardboard, and gives the cubic feet per minute for air-ways 1 x 1 foot up to 10 x 10 feet, length 1,000 feet, with pressures from 1-10 to 5 inches, water gage. The tables are calculated by Atkinson's formula:

$$Q = \sqrt{\frac{P \times A}{K \times S}} \times A\,;\ K = 0.0000000217.$$

TESTS OF CONCRETE AND REINFORCED CONCRETE COLUMNS, Series of 1906. By Arthur N. Talbot. 64 pages, 6 x 9 inches. Published by the University of Illinois, Urbana, Ill.

This is Bulletin No. 10, issued by the University of Illinois' Engineering Experiment Station, and is of interest and value to all engaged in reinforced concrete work. Comparatively few tests have been made on concrete columns and most of these were made on small test specimens. Tests described in this bulletin were made on the 600,000-pound testing machine belonging to the University.

CAMBRIA STEEL: HANDBOOK OF USEFUL INFORMATION FOR ENGINEERS. Compiled by George E. Thackray. 468 pages, 4¼ x 6¾ inches. Published by the Cambria Steel Co., Philadelphia.

This book is of the eighth edition. It contains the usual matter found in handbooks of this class, being confined in general to information on structural shapes, giving weights, dimensions, properties of sections, and other matter required by the engineer when specifying steel for structural work. The typographical appearance of the book is good; it is well printed and well bound, and will be highly appreciated by those interested. In addition to the general matter, there are tables of areas and circumferences of circles, trigonometrical tables and miscellaneous information.

TESTS OF REINFORCED CONCRETE T-BEAMS, Series of 1906. By Arthur N. Talbot. 35 pages, 6 x 9 inches. Published by the University of Illinois, Urbana, Ill.

This is Bulletin No 2, issued by the University of Illinois' Engineering Experiment Station. It describes a preliminary series of tests on reinforced concrete T-beams undertaken to determine the effect of different widths of beam which may be considered to contribute to the strength and stiffness of a beam. The tests also were made to determine the effectiveness of the metallic web reinforcement. The beams were reinforced with longitudinal rods, having a cross-section area equivalent to 1 per cent of the rectangle enclosing the beam. All the beams failed through tension in the longitudinal reinforcement.

OPEN-HEARTH STEEL CASTINGS. By W. M. Carr. 118 pages, 5 x 7½ inches. 19 cuts. Published by the Penton Publishing Co., Cleveland, Ohio. Price, $1.50.

This book is an exposition of the methods involved in the manufacture of open-hearth steel castings by the basic and acid processes, and is compiled from a series of articles by the author published in the *Iron Trade Review* and the *Foundry*. It treats of the open-hearth furnace construction, fuels and accessories, manipulation of heats in acid process and basic practice, order of charging, chemical analyses and physical tests, blow-holes in steel castings, heat treatment and annealing, repair of steel castings with thermit, cost of equipment for open-hearth steel foundries, etc. The growth of the use of steel castings and the superiority of the open-hearth process for low-grade ores make this book of much interest to all concerned with foundry practice and general machine construction.

TECHNICAL YEAR BOOK, 1907. 399 pages, 4 x 6 inches. Illustrated. Edited by Arthur C. Kelly and Charles Weekes. Published by Percival Marshall & Co., London. Price, cloth, $1.25; leather, $1.65.

This book is composed of a collection of the principal technical articles of permanent value that have appeared in the 250-odd engineering journals published throughout the world. It has chapters entitled automobiles, boilers and steam generation, cables and power transmission, electricity supply, general electrical, general mechanical, generators and motors, hydraulics, lighting, marine, mining, power, prime movers, traction and general. The guiding principle of selection is that the matter chosen shall have in a marked degree a permanent and general value as well as present interest, and it appears that the authors have made a good selection. The limit of space available has necessarily crowded out much matter that could have been used appropriately. It is hoped that the scheme will prove of sufficient popularity to admit of a substantial increase of size for succeeding years.

AMERICAN PATTERN SHOP PRACTICE. By H. J. McCaslin. 308 pages, 6 x 9 inches. Illustrated. Published by the Frontier Co., Cleveland, Ohio. Price $3.00.

This work is divided into six sections, as follows: Engineer Pat-

terns, Molding and Cores, Sweep Work, Gearing, Representative Patterns, and Hints, Suggestions and Rigs. Each section is separately paged, and the cuts separately numbered, the idea being to add to each section in future editions without disturbing the numbering of the pages and cuts throughout, as necessarily follows when the cuts and pages are consecutively numbered. The author is fairly well known to the readers of trade papers, having contributed valuable articles on pattern work to the press. Several of these articles substantially appear in the work, being modified to suit the conditions of the work. The line illustrations are all wax engravings and the general typographical appearance of the book is good. We believe that the book is one that will be appreciated by pattern-makers generally, inasmuch as the number of available books on pattern-making is very limited, and as this is a strictly practical work written by one who is master of his craft.

THE SEVEN FOLLIES OF SCIENCE. By John Phin. 178 pages, 5¼ x 7½ inches. 34 illustrations. Published by D. Van Nostrand Co., New York. Price $1.25.

This interesting book is one that should have a place in every public library. The main part of the book is taken up with discussions of the "seven follies of science," namely: squaring the circle; the duplication of the cube; tri-section of an angle; perpetual motion; the transmutation of metals; fixation of mercury; and the elixir of life. The problem of squaring the circle, that is, finding an exact mathematical equivalent for the area of any circle in the shape of a square, is one that has absorbed the energies of many would-be mathematicians, but it has been conclusively demonstrated that the circumference of a circle is incommensurable with its diameter. Hence the impossibility of establishing exact mathematical equivalent in a square for the area of a circle, although we are able to express the ratio of the circumference to the diameter to almost any required degree of accuracy save actual exactness. One English mathematician figured the value of π to 707 places. This problem and others of the same kind are still discussed more or less, but scientists no longer concern themselves with these ancient puzzles, as they now have something of much greater worth to investigate. The chapter on perpetual motion is probably the most interesting of all to mechanics. It illustrates a number of the weird and foolish schemes that have been devised for cheating nature and producing power without giving an equivalent. The book also contains brief discussions of minor follies known as perpetual lamps, universal solvent, palingenesy, the powder of sympathy, and interesting illusions of the senses; also a discussion of the fourth dimension, etc.

NEW TRADE LITERATURE.

THE GENERAL PNEUMATIC TOOL CO., Montour Falls, N. Y. Bulletin No. 58, on electric traveling cranes, describing features of construction.

NORTON CO., Worcester, Mass. Pamphlet entitled Testing for Safety, describing this company's system of testing Norton grinding wheels.

B. F. STURTEVANT CO., Boston, Mass. Bulletin 146 of electric propeller fans, illustrating and describing various forms of this type of fan for moving air.

FLANNERY BOLT CO., Pittsburg, Pa. Leaflet of Tate flexible stay-bolt for locomotive boilers, giving requirements that should be complied with in the construction and application of flexible stay-bolts.

IDEAL OPENING DIE CO., 24 West St., New York. Catalogue descriptive of the "Ideal" opening die, which utilizes the torsion due to threading to open the dies when the limit of thread has been reached.

REVOLUTE MACHINE CO., 523 West 45th St., New York City. Catalogue of the Everett-McAdam blue-print machine describing its parts, principle and efficiency.

THE S. OBERMAYER CO., Cincinnati, O., has issued a set of circulars setting forth the advantages claimed for Ceylon plumbago and other products manufactured by this company.

PH. BONVILLAIN & E. RONCERAY, Paris. Catalogue describing the "Universal" system of machine molding developed by this concern. This company exhibited examples of its product at the Convention of the American Foundrymen's Association held in Philadelphia in May.

T. R. ALMOND MFG. CO., 83 Washington Street, Brooklyn, N. Y. Catalogue of Almond drill chucks, Almond right angle transmission, Almond turret heads, Almond flexible arms for electric lights, and Almond flexible steel tubing.

FERRACUTE MACHINE CO., Bridgeton, N. J. Catalogue No. 15, being a temporary issue of their regular catalogue referring to nearly 500 kinds and sizes of foot and power presses for working bar and sheet metals, paper, cloth, leather, etc.

TABELL ANGAENDE SKÖTSEL AF DYNAMOMASKINER, being a translation by Sigurd Christenson of MACHINERY's data sheet supplement "Diseases of Dynamos and Motors," September, 1906. This has been printed in pamphlet form for use in the Coast Artillery Schools of Sweden.

WESTERN ELECTRIC CO., Chicago, Ill. Pamphlet entitled "Some Interesting Western Electric Co. Facts," mentioning houses and agencies, principal manufactures, system throughout the plant, etc. Also a pamphlet containing instructions for installation and maintenance of telephone machines.

THE BILLINGS & SPENCER CO., Hartford, Conn., has divided its present issue (1907) of circulars into two books, one being a general catalogue of machinists' tools, etc., the other being devoted to fine tools and specialties. Both are illustrated and contain descriptions and price lists of these tools.

GISHOLT MACHINE CO., 1316 Washington Ave., Madison, Wis. New catalogue illustrating and describing Gisholt lathes (American type). The American semi-automatic turret lathe described is especially adapted for finishing such classes of work as gear blanks, cylinder heads, fly wheels, pulleys, etc., up to full swing of machine.

WM. GARDAM & SON, INC., 45-51 Rose Street, N. Y. Bulletins No. 2 and 14 of sensitive drill presses. These include very light bench sensitive drills and column sensitive drills having a capacity up to ½-inch hole.

CINCINNATI MACHINE TOOL CO., Western Avenue and Frank Street, Cincinnati, Ohio. Catalogue of the Cincinnati upright drilling and tapping machines. Special attention is called to the patent gear tapping attachment with which about half the annual product of the company is now equipped. The company has a new three-story plant, which is illustrated in catalogue.

JOSEPH DIXON CRUCIBLE CO., Jersey City, N. J. Booklet, A Study in Graphite, by Prof. W. F. M. Goss, giving in detail a series of tests made by him at Purdue University. The book opens with a dissertation by Prof. Goss based on the conclusions drawn from the results of the tests. Then follow complete descriptions of the tests together with illustrations of the testing machine.

BROWN & SHARPE MFG. CO., Providence, R. I. Eight-page catalogue describing new machinist's tools. These tools are a removable point pocket scriber; spacing attachment for automatic center punches; pocket automatic center punch; combination caliper and divider; micrometer caliper set, range 0 to 3 inches; short steel rules (5) with holder for measuring in constricted places such as keyways, etc.

FORBES COMPANY, Philadelphia, Pa. Catalogue descriptive of the Forbes system of sterilization for drinking water of plants, mills and factories, and all concerns employing labor. The matter of supplying safe drinking water to the employes of manufacturing plants is of great importance, not only from the humanitarian view-point, but for business reasons as well. The Forbes system is used by the Link-Belt Company, Philadelphia.

THE English edition of *La Revue de l'Ingenieur et Index Technique* will in future be published by Mr. M. J. Fitz-Patrick, 51 rue de l'Aurore, Brussels, under the title of *The Technical Index*. This publication is a systematic record of current literature of the world. It lists the important articles of the technical press, proceedings of technical societies and new books on technical subjects. The subjects are classified by the Dewey decimal system. The subscription price of the ordinary edition is $2.50 yearly, and of the card index edition, $4.00.

WESTERN ELECTRIC CO., Chicago, Ill., is about to issue the 1907 edition of its supply catalogue. This will be a volume of 700 pages, and will list everything of importance in the electrical line. The supply catalogue gotten out by the company in the past few years has been greatly in demand by dealers and others all over the country, because it contains not only a complete list of the material handled by the company, but features of general interest to the electrical trade. The present edition will be much more complete and instructive than any heretofore published by the company.

MANUFACTURERS' NOTES.

WELLS BROS. CO., Greenfield, Mass., has moved its New York store from 56 Reade St. to 126 Chambers St.

THE New York offices of the *Iron Trade Review* have been changed from 150 Nassau Street to the new West Street building, 90 West Street.

THE CASE MFG. CO., Columbus, O., manufacturer of cranes, has just completed a large addition to its factory which will increase the output about 30 per cent.

SPRAGUE ELECTRIC CO., New York, is manufacturing and marketing the dynamo-dynamometers for testing automobile engines, developed by Mr. Joseph Tracy.

F. H. BROWN MACHINERY CO. has opened an office at 1102 Park Building, Pittsburg, Pa., where a number of machine tool manufacturers will be represented. The company will also buy and sell second-hand machinery.

NORTON GRINDING CO., Worcester, Mass., manufacturer of cylindrical grinding machinery, bench and floor grinding machinery, universal tool and cutter grinders, is erecting a building which will double the present capacity of the company.

NORTHERN ENGINEERING WORKS, 26 Chene St., Detroit, Mich., has furnished the plant of the Edison Sault Electric Co., Sault Ste. Marie, Mich., with a second 15-ton alternating current electric traveling Northern crane.

EBERHARDT BROS. MACHINE CO., 66 Union St., Newark, N. J., gear specialist, is building a one-story addition to its factory. The extension will accommodate several new planers, and a new engine room, and will increase the production of automatic gear cutting machines.

FULTON MACHINE & VISE CO., Lowville, N. Y., advises us that its shop, machinery and patterns were destroyed by fire on Sunday, May 19. The company desires to obtain catalogues of all kinds pertaining to its business from various manufacturers, as its files were completely destroyed.

WILMARTH & MORMAN CO., 580 Canal St., Grand Rapids, Mich., will have an exhibit in space 984 at the American Railway Master Mechanics' Association Convention to be held at Atlantic City, N. J., June 12 to 19. The secretary of the company, Mr. Charles E. Meech, will be in charge.

GENERAL ELECTRIC CO., Schenectady, N. Y., has now permanently located its San Francisco offices in the Union Trust building, in San Francisco. Since the fire the office had been located in the Union Savings Bank building, at Oakland, large temporary warehouses having been erected in the same city.

J. H. WAGENHORST & CO., Youngstown, Ohio, recently sold Wagenhorst electric blueprinting machines to the Babcock & Wilcox Co., Barbertown, Ohio; American Steel & Wire Co., Joliet, Ill.. Monongehela River Consolidated Coal & Coke Co., Pittsburg, Pa.; Thompson Stationary Co., Vancouver, B. C., and others.

THE ROBBINS & MYERS CO., Springfield, Ohio, recently moved its New York office and salesroom from 66 Cortlandt St. to 145 Chambers St., where the company occupies a 5-story building. The new location provides good facilities for carrying a larger stock and making prompter deliveries than before. The increase in their Eastern business in the power motor and fan motor line made the change necessary.

L. H. GILMER & CO., Philadelphia, Pa., have incorporated their business under the name of L. H. Gilmer Co., with a capital stock of $100,000. Mr. Ludwell H. Gilmer is the president of the concern, and Mr. G. W. Gilmer, Jr., vice-president. The company will have increased facilities for manufacturing the Gilmer belting and endless belts, and will also carry on a jobbing business in machinery and supplies.

HILL, CLARKE & CO., INC., have removed their New York store to the West Street Building, 136 Cedar Street, occupying the northwest corner of the ground floor. Their new quarters are much larger than the old, and unusually well adapted to their business on account of the excellent light, arrangement and other features. The location is convenient to the machinery trade, and many concerns in their line have offices in the West Street Building.

THE F. W. SPACKE MACHINE CO., Indianapolis, Ind., has completed a two-story addition to its factory, each floor containing about 10,000 square feet of floor space. The company recently purchased the entire machinery equipment of a local machine shop retiring from business, and this will be installed along with the new equipment. The additional machinery and space will about double the capacity of the company.

THE MICHIGAN CRUCIBLE STEEL CASTINGS CO., 248-250 Guoin St., Detroit, Mich., has been incorporated under the laws of the state of Michigan for the purpose of manufacturing crucible steel castings, special attention being paid to automobile work. The firm expects to be ready to produce castings on or before the first of May. The president and general manager of the company is R. F. Flinterman and the superintendent of the plant is Mr. MacLeod.

NORTON CO., Worcester, Mass., manufacturer of grinding wheels made of Alundum and other abrasive specialties, is to erect a large addition to its Worcester works. The building designated as Plant will be extended to about 200 feet in length by 111 feet in width, which will more than double the present capacity. The building will also be fully equipped with kilns, mixing machines, shaving machines, etc., so as to permit of a large increase in output.

EBERHARDT BROS. MACHINE CO., 66 Union St., Newark, N. J., announces that, because of the continued increase in the number of orders for its automatic gear-cutting machines and crank shapers, the company will discontinue the manufacture of crank shapers, and will give exclusive attention to its specialty, the design and manufacture of automatic gear-cutting machines and gearing. The Machine Sales Co., of New York City, has arranged to take over the production of the shapers, and will manufacture them at its plant at Peabody, Mass. There will, therefore, be no interruption in the supply to the market.

DIMENSIONS FOR HUNG BOILERS.—I.

BOILER	Horse-Power of Boiler	15	20	25	30	35	40	45	50	55	60	70	75
BOILER	Diameter of Boiler (inches)	36	36	36	40	42	46	48	48	52	54	54	60
BOILER	Length of Tubes (feet)	8	10	12	12	12	12	12	14	14	14	16	14
BOILER	Total length of Shell (feet)	9½	11½	13½	13½	13½	13½	13½	15½	15½	15½	17½	15½
BOILER	Total weight in pounds (approx) of Boiler and Fixtures	4250	4640	5300	6400	7300	8250	8840	9650	11800	12900	15500	17100
BOILER	Total weight in pounds (approx) of Water	2800	3500	4200	5100	5800	6900	7700	9000	10200	11300	12900	13500
BOILER	Total weight in pounds (approx) of Boiler, Fixtures and Water	7050	8140	9500	11500	13100	15150	16540	18650	22000	24200	28400	30600
HANGER BOLTS	Front Head to center of Hanger (inches)	5	9	12	12	12	12	12	17	17	17	25	17
HANGER BOLTS	Rear Head to center of Hanger (inches)	15½	18½	23½	23½	23½	23½	23½	31½	31½	31½	31½	31½
HANGER BOLTS	Center to center of Hangers (inches)	75½	92½	108½	108½	108½	108½	108½	119½	119½	119½	135½	119½
HANGER BOLTS	Diameter of Hanger Bolts (inches)	1	1	1	1	1	1	1	1	1¼	1¼	1¼	1¼
HANGER BOLTS	Length of Hanger Bolts (inches) using I-Beams — one Boiler	19	19	20	19	18	28	27	27	32	30	32	44
HANGER BOLTS	Length of Hanger Bolts (inches) using I-Beams — two Boilers	23	23	23	22	21	31	30	30	35	34	35	47
HANGER BOLTS	Length of Hanger Bolts (inches) using I-Beams — three Boilers	25	25	25	24	23	34	33	33	38	39	40	52
HANGER BOLTS	Length of Hanger Bolts (inches) using Channel Beams — one Boiler	20	21	22	21	20	30	29	29	35	33	34	46
HANGER BOLTS	Length of Hanger Bolts (inches) using Channel Beams — two Boilers	25	25	25	24	23	34	33	33	38	36	37	49
HANGER BOLTS	Length of Hanger Bolts (inches) using Channel Beams — three Boilers	27	27	27	26	25	37	36	36	41	39	40	52
COLUMNS	Center to center of Columns (inches) — one Boiler	69	69	69	73	75	78	87	87	92	94	94	110
COLUMNS	Center to center of Columns (inches) — two Boilers	124	124	124	136	140	150	161	161	170	173	173	195
COLUMNS	Center to center of Columns (inches) — three Boilers	180	180	180	200	206	222	234	234	247	253	253	281
COLUMNS	Length of Columns (feet)	8	8	8	8½	8½	9½	9½	9½	10	10	10	11½
COLUMNS	Diameter of C.I. Columns (inches) — one Boiler	4	4	4	4	4	5	5	5	5	5	5	5
COLUMNS	Diameter of C.I. Columns (inches) — two Boilers	5	5	5	5	5	5	5	5	5	6	6	6
COLUMNS	Diameter of C.I. Columns (inches) — three Boilers	5	5	5	5	5	5	6	6	6	6	6	6
COLUMNS	Thickness of Metal of C.I. Columns (inches) — one Boiler	½	½	½	½	½	½	½	½	½	½	½	½
COLUMNS	Thickness of Metal of C.I. Columns (inches) — two Boilers	½	½	½	½	½	⅝	⅝	⅝	⅝	⅝	⅝	⅝
COLUMNS	Thickness of Metal of C.I. Columns (inches) — three Boilers	⅝	⅝	⅝	¾	¾	¾	⅝	⅝	⅝	⅝	⅝	¾
COLUMNS	Size of Cap and Base of C.I. Columns (inches) — one Boiler	8×8	8×8	8×8	8×8	8×8	9×9	9×9	9×9	9×9	9×9	10×10	10×10
COLUMNS	Size of Cap and Base of C.I. Columns (inches) — two Boilers	10×10	10×10	10×10	10×10	10×10	10×10	10×10	10×10	10×10	12×12	12×12	12×12
COLUMNS	Size of Cap and Base of C.I. Columns (inches) — three Boilers	12×12	12×12	12×12	12×12	12×12	12×12	12×12	12×12	12×12	13×13	13×13	13×13

Contributed by G. L. Preacher.

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DIMENSIONS FOR HUNG BOILERS.—II.

I-BEAMS AND CHANNELS	Horse-Power of Boiler	15	20	25	30	35	40	45	50	55	60	70	75
I-BEAMS AND CHANNELS	Center to center of Boilers (inches)	56	56	56	64	66	72	74	74	78	80	80	86
I-BEAMS AND CHANNELS	Length of I-Beams or Channel Beams required for (inches) — one Boiler	77	77	77	81	83	88	98	98	102	104	104	120
I-BEAMS AND CHANNELS	Length of I-Beams or Channel Beams required for (inches) — two Boilers	134	134	134	146	150	160	171	171	180	185	185	207
I-BEAMS AND CHANNELS	Length of I-Beams or Channel Beams required for (inches) — three Boilers	192	192	192	210	218	234	246	246	259	266	266	294
I-BEAMS AND CHANNELS	Size of I Beams required for (inches) — one Boiler	4	4	5	5	5	6	6	6	6	6	7	7
I-BEAMS AND CHANNELS	Size of I Beams required for (inches) — two Boilers	8	8	8	8	8	9	9	9	9	10	10	10
I-BEAMS AND CHANNELS	Size of I Beams required for (inches) — three Boilers	10	10	10	10	10	12	12	12	12	15	15	15
I-BEAMS AND CHANNELS	Size of Channel Beams required for (inches) — one Boiler	5	6	7	7	7	8	8	8	9	9	9	9
I-BEAMS AND CHANNELS	Size of Channel Beams required for (inches) — two Boilers	10	10	10	10	10	12	12	12	12	12	12	12
I-BEAMS AND CHANNELS	Size of Channel Beams required for (inches) — three Boilers	12	12	12	12	12	15	15	15	15	15	15	15
I-BEAMS AND CHANNELS	Weight per foot of I-Beams required for (pounds) — one Boiler	7½	8½	9¾	9¾	12¼	12¼	12¼	12¼	14¾	14¾	15	15
I-BEAMS AND CHANNELS	Weight per foot of I-Beams required for (pounds) — two Boilers	17¾	17¾	17¾	20¼	20¼	21	21	21	21	25	25	25
I-BEAMS AND CHANNELS	Weight per foot of I-Beams required for (pounds) — three Boilers	25	25	25	30	30	31½	31½	35	35	42	42	42
I-BEAMS AND CHANNELS	Weight per foot of Channel Beams required for (pounds) — one Boiler	6½	8	9¾	9¾	9¾	11¼	11¼	11¼	13¼	13¼	13¼	13¼
I-BEAMS AND CHANNELS	Weight per foot of Channel Beams required for (pounds) — two Boilers	15	15	15	20	20	20½	20½	20½	20½	25	25	25
I-BEAMS AND CHANNELS	Weight per foot of Channel Beams required for (pounds) — three Boilers	25	25	25	25	25	33	33	33	33	55	55	55
BRICK	Number of Fire Bricks required to set — one Boiler	600	700	800	850	875	900	950	1050	1300	1350	1400	1450
BRICK	Number of Fire Bricks required to set — two Boilers	1200	1400	1600	1700	1750	1800	1900	2100	2600	2700	2800	2900
BRICK	Number of Fire Bricks required to set — three Boilers	1800	2100	2400	2550	2625	2700	2850	3150	3900	4050	4200	4350
BRICK	Number of Common Bricks required to set — one Boiler	4100	4200	4800	6800	7200	9300	10300	11400	13600	14000	14500	15800
BRICK	Number of Common Bricks required to set — two Boilers	7150	7300	8400	11900	12400	16100	16700	18525	22100	22750	23600	25700
BRICK	Number of Common Bricks required to set — three Boilers	10200	10500	12000	17000	17600	20900	23100	25650	30600	31500	32700	35550

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DIMENSIONS FOR HUNG BOILERS—III.

BOILER	Horse-Power of Boiler	85	90	100	115	125	150	175	175	200	200	225	225	250
	Diameter of Boiler (inches)	60	66	66	66	72	72	72	78	78	84	84	90	90
	Length of Tubes (feet)	16	15	16	18	16	18	20	18	20	18	20	18	20
	Total length of Shell (feet)	17½	16½	17½	19½	17½	19½	21½	19½	21½	19½	21½	19½	21½
	Total weight in pounds (approx) of Boiler and Fixtures.	19400	21000	23700	25100	28000	29500	30800	32090	34100	34500	36200	37000	39000
	Total weight in pounds (approx) of Water.	15400	15500	16500	18550	20800	23400	26000	28400	31600	33000	36800	37500	40000
	Total weight in pounds (approx) (of Boiler, Fixtures and Water.	34800	36500	40200	43650	48800	52900	56800	60400	65700	67500	73000	74500	79000
HANGER BOLTS	Front Head to center of Hanger (inches)	25	21	25	25	25	25	25	25	25	25	25	25	25
	Rear Head to center of Hanger (inches)	31½	31½	31½	31½	31½	31½	31½	31½	31½	31½	31½	31½	31½
	Center to center of Hangers (inches)	135½	127½	135½	159½	135½	159½	183½	159½	183½	159½	183½	159½	183½
	Diameter of Hanger Bolts (inches)	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½	1½	1½	1½	1½	1½
	Length of Hanger Bolts (inches) using I-Beams — one Boiler	44	41	41	41	39	39	39	49	50	53	53	56	56
	Length of Hanger Bolts (inches) using I-Beams — two Boilers	49	46	46	46	46	46	45	58	58	61	61	64	66
	Length of Hanger Bolts (inches) using I-Beams — three Boilers	52	49	52	52	49	51	50	64	64	67	67	70	70
	Length of Hanger Bolts (inches) using Channel Beams — one Boiler	46	43	43	43	41	41	42	52	52	55	55	58	58
	Length of Hanger Bolts (inches) using Channel Beams — two Boilers	52	49	49	49	46	46							
	Length of Hanger Bolts (inches) using Channel Beams — three Boilers													
COLUMNS	Center to center of Columns (inches) — one Boiler	110	115	115	115	121	121	121	126	126	132	132	138	138
	Center to center of Columns (inches) — two Boilers	195	207	207	207	219	219	219	230	230	242	242	254	254
	Center to center of Columns (inches) — three Boilers	281	299	299	299	316	316	316	333	333	351	351	369	369
	Length of Columns (feet)	11½	11½	11½	11½	11½	11½	11½	12½	12½	13	13	13½	13½
	Diameter of C.I. Columns (inches) — one Boiler	5	6	6	6	6	6	6	7	7	7	7	7	7
	Diameter of C.I. Columns (inches) — two Boilers	6	6	6	6	6	6	6	7	7	7	7	7	7
	Diameter of C.I. Columns (inches) — three Boilers	6	6	6	6	7	7	7	8	8	8	8	8	8
	Thickness of Metal of C.I. Columns (inches) — one Boiler	½	⅝	⅝	⅝	⅝	⅝	⅝	⅝	⅝	¾	¾	¾	¾
	Thickness of Metal of C.I. Columns (inches) — two Boilers	⅝	¾	¾	¾	¾	¾	¾	¾	¾	¾	¾	1	1
	Thickness of Metal of C.I. Columns (inches) — three Boilers	¾	⅞	⅞	⅞	¾	¾	¾	¾	¾	1	1	1	1
	Size of Cap and Base of C.I. Columns (inches) — one Boiler	10×10	10×10	10×10	10×10	10×10	10×10	12×12	12×12	12×12	12×12	12×12	12×12	12×12
	Size of Cap and Base of C.I. Columns (inches) — two Boilers	12×12	12×12	12×12	12×12	13×13	13×13	13×13	14×14	14×14	14×14	14×14	14×14	15×15
	Size of Cap and Base of C.I. Columns (inches) — three Boilers	13×13	13×13	14×14	14×14	14×14	15×15	15×15	16×16	16×16	16×16	16×16	16×16	16×16

Contributed by G. L. Preacher.

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DIMENSIONS FOR HUNG BOILERS.—IV.

I-BEAMS AND CHANNELS	Horse-Power of Boiler	85	90	100	115	125	150	175	175	200	200	225	225	250
	Center to center of Boilers (inches)	86	92	92	92	98	98	98	104	104	110	110	116	116
	Length of I-Beams or Channel Beams required for (inches) — one Boiler	120	127	127	127	133	133	133	140	140	146	146	152	152
	Length of I-Beams or Channel Beams required for (inches) — two Boilers	207	219	219	219	232	232	232	244	244	256	256	268	268
	Length of I-Beams or Channel Beams required for (inches) — three Boilers	294	312	313	313	330	331	331	349	349	367	367	385	385
	Size of I-Beams required for (inches) — one Boiler	7	7	7	7	8	8	9	9	10	10	10	10	10
	Size of I-Beams required for (inches) — two Boilers	12	12	12	12	15	15	15	18	18	18	18	18	20
	Size of I-Beams required for (inches) — three Boilers	15	15	18	18	18	20	20	24	24	24	24	24	24
	Size of Channel Beams required for (inches) — one Boiler	9	9	9	9	10	10	12	12	12	12	12	12	12
	Size of Channel Beams required for (inches) — two Boilers	15	15	15	15	15	15							
	Size of Channel Beams required for (inches) — three Boilers													
	Weight per foot of I-Beams required for (pounds) — one Boiler	15	17½	17½	17½	17¾	20¼	21	25	25	25	30	30	30
	Weight per foot of I-Beams required for (pounds) — two Boilers	31½	31½	35	40	42	42	45	55	55	55	60	60	65
	Weight per foot of I-Beams required for (pounds) — three Boilers	45	45	55	55	60	65	65	80	80	80	85	85	90
	Weight per foot of Channel Beams required for (pounds) — one Boiler	13¼	15	15	15	15	20	20½	20½	25	25	30	30	30
	Weight per foot of Channel Beams required for (pounds) — two Boilers	33	33	33	40	55	55							
	Weight per foot of Channel Beams required for (pounds) — three Boilers													
BRICK	Number of Fire Bricks required to set — one Boiler	1550	1650	1700	1800	1850	1900	1950	2000	2050	2100	2100	2150	2200
	Number of Fire Bricks required to set — two Boilers	3100	3300	3400	3600	3700	3800	3900	4000	4100	4200	4200	4300	4400
	Number of Fire Bricks required to set — three Boilers	4650	4950	5100	5400	5550	5700	5850	6000	6150	6300	6300	6450	6600
	Number of Common Bricks required to set — one Boiler	17500	18000	18300	18500	19000	20800	22000	22800	23900	24100	26000	27000	29000
	Number of Common Bricks required to set — two Boilers	28500	29250	29800	30100	30800	33800	35750	37050	38900	39150	42250	43900	47100
	Number of Common Bricks required to set — three Boilers	39500	40500	41300	41700	42600	46800	49500	51300	53900	54200	58500	60800	65250

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